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ORIGINAL ARTICLES.

I.—On a new Cynodont from the Stormberg.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology in the University College, London.

When I visited the town of Burghersdorp, Cape Colony, with the aid of a grant from the Percy Sladen Trustees, I was given by Mr. Maasdorp, the district surveyor, some fossil bones which he had collected at a locality on the farm Witkop, District Albert. Subsequently, through the kindness of D. V. Kannemeyer, Esq., its owner, I had the opportunity of examining the spot and obtained remains of Theropodous Dermosaurs, showing, as was already perfectly clear from its stratigraphical relations, that the locality lay in the 'Red Beds' of the Stormberg Series far above the *Cynognathus* beds of Burghersdorp, which have yielded so many Cynodont remains.

Fig. 1. Right ramus of the lower jaw of *Pachygenelus monus*, gen. et sp. nov. From the Red Beds, Stormberg Series, Witkop, District Albert, Cape Colony. Nat. size. A outer, B inner aspect.

The most important of Mr. Maasdorp's fossils was the anterior part of a small dentary belonging to an animal about as large as a fox terrier. This jaw seems to be certainly a 'Cynodont', and is the second specimen of that 'Order' found at so high a horizon. The specimen is represented in Fig. 1. Like all 'Cynodont' dentaries it is of a very mammalian appearance, the sole feature serving to distinguish it from the lower jaws of the latter group being the presence of a splenial, indicated by a step on the inner side which formerly received it. The symphysis is not fused, the symphysial face being well preserved and so placed as to show that the anterior part of the jaw was narrow, the two rami behind it separating more widely.

The interest of the specimen lies in its very unusual dentition. There are only two incisors, represented only by their roots. I_1 is a large tooth of oval section, which appears to be somewhat

procumbent and lies close up to the symphysis. I_2 is a considerably smaller tooth, also of oval section, which lies close behind and outside I_1. The canine is a large tooth whose root, the only part preserved, is of oval section. It seems to have pointed directly upwards, and immediately follows I_2. Behind the canine is a long diastema, which is followed by a series of cheek teeth, six of which are preserved before the fracture which terminates the specimen. These teeth are small, single-rooted, and narrow from side to side; the root is deep and closely fits its alveolus. Only 3, 4, and 5 show anything of the crown, and even these are mutilated; they seem to be much alike, and a description of the last may serve for all. The crown is of an irregular oval shape, widest in front, where it is about three-quarters of its length. There are four cusps arranged longitudinally and forming the outer side of the tooth; the summits of the anterior three of these are broken, but it is certain that the first

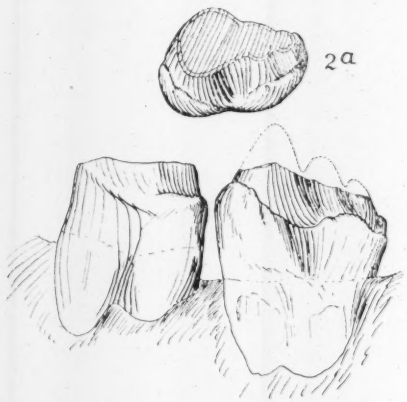


FIG. 2. The fourth and fifth molars of the right side of the lower jaw of *Pachygenelus monus*, gen. et sp. nov. × 8. Inner aspect.
,, 2*a*. The fifth molar viewed from above.

was much the largest and that they gradually declined in size and height to the fourth. On the inner side is a strong cingulum, whose position will be best understood from the figures. This shows a very faint crimping, as if in the descendants of our animal it might have developed cusps.

The systematic position of this specimen is difficult to determine; it is either a 'Cynodont' or a mammal. The occurrence of a splenial suggests reference to a former group, although it is exceedingly probable that a splenial did occur in the most primitive mammals.

The only known 'Cynodont' from the same horizon is *Tritherlodon riconi*, Broom, of which only upper molars are known; the type differs from ours fundamentally in the structure of the molars, which are transversely widened. All the other 'Cynodonts' differ in having more than two lower incisors, the Bauridæ offering the best comparison in that their incisors are large and somewhat procumbent.

They have, however, transversely widened molar teeth. *Tribolodon* differs in its much more slender jaw and scattered teeth. It is thus certain that our jaw, for which I propose the name *Pachygenelus monus*, belongs not only to a new genus and species, but also probably to a new family of 'Cynodonts'.

It may be of interest to discuss briefly the derivation of the molar teeth of *Diademodon*, not only for the intrinsic interest of the subject, but also for its bearing on the Tritubercular and allied theories of mammalian tooth development. As Broom has pointed out, the resemblance between *Cynognathus* and *Diademodon* is so close as to show that the two types with *Trirachodon* form a compact group of 'Cynodonts', and that it is very probable that the *Trirachodon* molar has been derived from a condition similar to that of *Diademodon*, which in turn comes from a type like that of *Cynognathus*. There is also no doubt that all three are descended from 'Therocephalian'

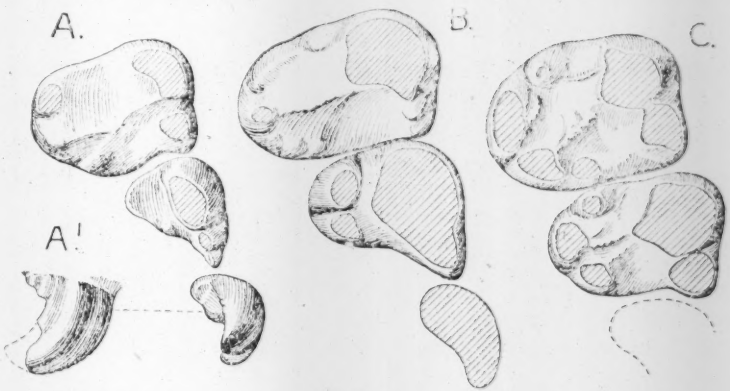


FIG. 3.

A. The three last molars of *Diademodon browni*. × 3.
A¹. The last molar of *D. browni*, external aspect. × 3.
B. The three last molars of *D. entomophonus*. × 3.
C. ,, ,, *D. mastacus*. × 3.

ancestors, having simple conical molars, of which those of the maxillæ bite outside the series in the lower jaw. In Theriodonts modification of such teeth apparently invariably begins by the addition of little cusps in front and behind the main primitive cusp: cf. *Cynognathus*, *Nythosaurus*, *Galesaurus*, *Tribolodon*. If we examine the last upper molar of *Diademodon browni*, Seeley, we find a tooth consisting of a high backwardly curved cusp, whose anterior border is obscurely crenated; immediately behind this large cusp are two much smaller ones. On the inner side of the main cusp is a short, heavy cingulum, divided into two small cusps. This tooth practically only differs from that of *Cynognathus* in the presence of the cingulum. The next tooth in front has a similar main cusp, with two smaller posterior cusps. The cingulum is, however, much further developed, and the anterior of the two cusps which it bears is worn down, lying at the

base of a vertically placed wear facet on the inner side of the main cusp. This tooth is obviously derived from a type similar to that behind it by the increase in size of the cingulum.

If we now turn to *Diademodon entomophonus*, Seeley, we find that the hind upper molar agrees in its section with the penultimate molar of *D. browni*; the crown is most unfortunately destroyed. The penultimate molar of *D. entomophonus* shows a further advance; there is still the large main cusp with a smaller posterior cusp, and the cingulum has grown considerably larger, but still supports the original two cusps on its inner side. If we compare this tooth with the corresponding tooth of *D. mastacus* we see a further change in the same direction; there is still the same main cusp with a smaller posterior cusp, but the cingulum is still further exaggerated and now has a small anterior in addition to the two original cusps. This tooth is identical in structure with the much worn antepenultimate molar of *D. browni* and is a typical *Diademodon* molar.

It must be clearly understood that these three species, which occur together, do not stand in any phylogenetic relation to one another, but the series seems to give a clear idea of the origin of the upper molars of *Diademodon*, the 'protocone' being the antero-external cusp and the whole of the inner part of the crown developed by the hypertrophy of the cingulum. If this is the case for the upper molars, it will also follow for the lower teeth, because the main cusp of the upper molar always bites outside the whole lower tooth, and if the lower molar had developed in the reverse way to the upper it would bite into an exaggerated external cingulum. It is remarkable that the view of the origin of the crown of the *Diademodon* molar put forward above agrees exactly in its general lines with the theory of mammalian molar development supported from embryological evidence by M. F. Woodward and from the analogy of the premolar development by many American palæontologists.

II.—Geological Notes on the "Land of Deep Corrosions".

By F. Kingdon Ward, B.A., F.R.G.S.

(PLATES V AND VI.)

A YEAR spent amongst the high mountain ranges of the Yunnan–Tibet frontier, where the Salween, Mekong, and Yangtze Rivers have been pinched together till they now flow parallel to one another for 200 miles in a belt of mountainous country averaging about 75 miles in width, enabled me, while prosecuting my botanical exploration, to ascertain a few facts of geological interest which form the subject of the present paper (see Plates V and VI and Figs. 1–4). The Tibetans of Kham, with more eye for the picturesque than one would have given them credit for, have, with amazing intuition, appreciated the subtle distinction between a land of high mountains and a land of deep valleys, and in their classical writings refer to Tibet under the name of *Nam-grog-chi*, which, according to Mr J. H. Edgar, may be translated "the land of deep corrosions"; and this it undoubtedly is.

The Mekong–Yangtze Divide, looking south from the Chun-ma-la, showing screes and buttresses. Photograph taken at about 16,000 ft. elevation.

Before passing on to a description of the country it will be first necessary, for the sake of clearness, to say a few words about the distribution of rainfall and wind over this region, for while the main mountain ranges and valleys are clearly the result of crust movement, other minor topographical features are as clearly the direct result of local peculiarities in the distribution of these meteorological factors.

The prevailing wind is the south-west monsoon, which drenches the many parallel mountain ridges between Assam and China from

FIG. 1. The Yangtze in the arid region looking south, from near Batang, 3,000 miles from its mouth.

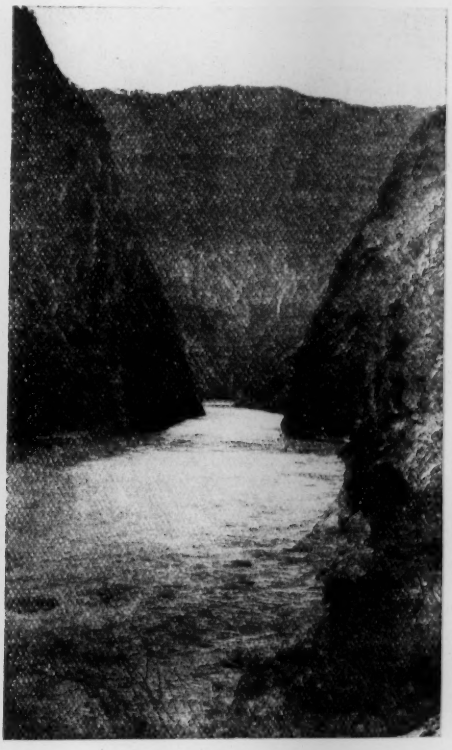


FIG. 2. The Salween River in the arid region, below La-kor-ah.

May to October. In about latitude 28°, however, the three main divides with which we are concerned receive such a considerable uplift that the westernmost acts as a partial rain-screen to the next, and so on. Thus there is, first, a high snowy range between the head-waters of the Irrawaddy and the Salween, a second between the Salween and the Mekong, and finally two isolated snow peaks between the Mekong and the Yangtze, all in about the same latitude.

This sudden uplift of the Salween–Irrawaddy divide is sufficient

to check the high rainfall of the Salween valley, and consequently we here pass abruptly from a region of dense forest to a region of semi-desert; the Mekong–Salween divide is even higher, so that while gathering to itself whatever remains of the moisture in the air, and boasting an equally heavy rainfall, the Mekong valley or gorge beyond is, if possible, more desiccated than the Salween valley. But after crossing two high ranges the winds have now little moisture left, so that not only is the Yangtze valley arid but the Mekong–Yangtze divide also (Plate V); thus it stands in marked contrast to the other two rain-drenched ridges.

To return to the valleys. The combined effect of high wall-like mountains and lack of rain causes a local wind to blow in each valley throughout the summer as the heated air rises and cold air sweeps down from the snows immediately above to take its place, and since

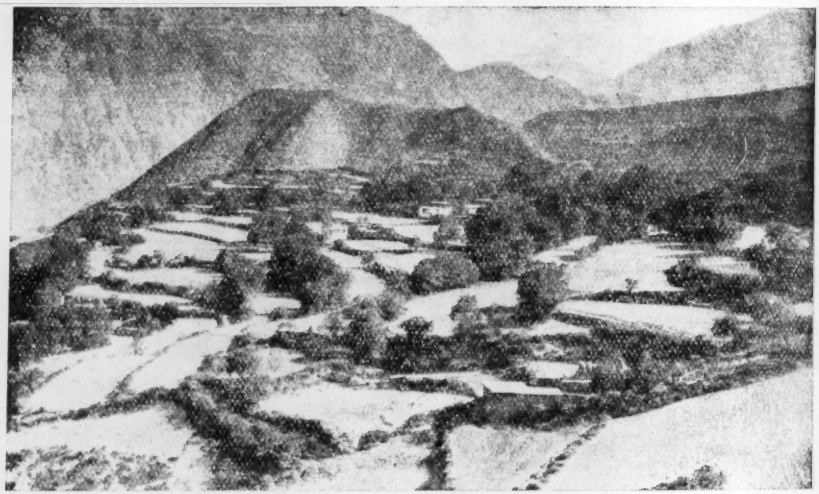
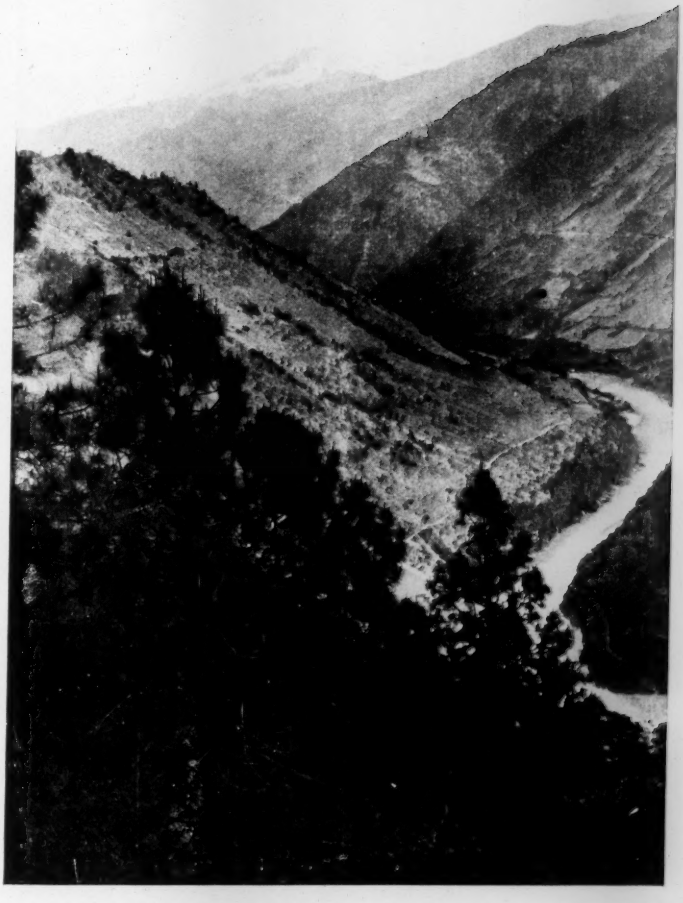


FIG. 3. An oasis in the arid region, Mekong River Valley, north of Yangtze.

the gorges get narrower towards the north the partial vacuum is more complete in this direction, and consequently the wind almost invariably blows from south to north up the valleys. It begins about ten o'clock in the morning, reaching its maximum intensity towards evening, and dies away about midnight or rather earlier. Meanwhile the rainfall has been reduced to a few inches a year, and from a distance the valley has the appearance of a desert, except where an alluvial cone, by permitting a little terracing and irrigation, forms an oasis (Fig. 3).

The most abrupt transition from luxuriant vegetation to semi-desert occurs on the Salween (Fig. 2), for the next two valleys are, to a certain extent, deprived of a copious rainfall even south of the snowy ranges, which we have called rain-screens; hence the transition, though obvious, is not so remarkable.



The Mekong River at Tew-kow, looking north, just before the arid region is reached; the Mekong–Yangtze Divide seen in the distance.

An excellent illustration of the almost physical barrier which seems to be stretched across these valleys at the northern limit of rain is sometimes seen, the clouds, from which rain may be falling at the time, stopping short suddenly, and a ribbon of blue sky following the river northwards, though heavy masses of cloud still rest on the mountain-tops immediately above.

The phenomenon also illustrates the local character of the up-valley winds, for the clouds are entirely unaffected by it, gradually sailing over from the south-west under the influence of the prevailing wind.

In the Mekong valley just south of the arid region brilliant sun haloes are frequent in the summer, usually heralding rain; they are probably caused by clouds which have been blown across from the western range only partially disappearing during their passage over the hot valley, leaving a film through which the sun is seen. The

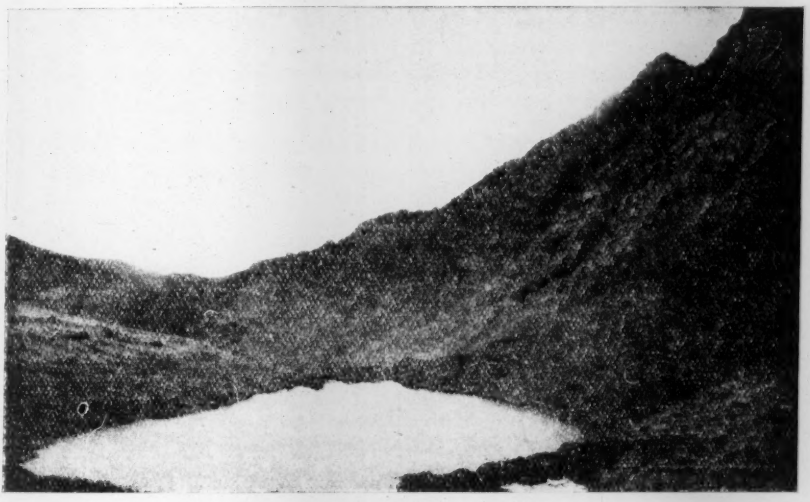


FIG. 4. Lake occupying a rock-basin at 16,000 feet on the Mekong–Yangtze Divide.

passage of clouds over the arid region on the other hand is often quite invisible, the rain drenching the western divide and later the eastern without affecting the intervening valley.

The effects of this abrupt change of climate in the Salween valley are various. In the first place the appearance of the valley changes from a typical U in cross section to a pronounced V, and at the same time the spurs change their direction from one of more or less parallelism to the main axis, to a direction more or less at right angles to it, thus forming as it were supporting buttresses.

Another change is to be noted in the tributary valleys which, in the arid region, exhibit to a very marked degree the 'reversed' type of structure, whereas in the more rainy regions to the south this structure, though sometimes apparent, is not nearly so conspicuous. [By a 'reversed' valley I mean a valley which begins in the mountains

with a wide opening and gradually contracts as it descends, till finally it slits open the enclosing wall of the main river with a narrow gorge, the last thousand feet or so being over a series of high falls, or, more usually, down a long stairway.]

More interesting is a comparison of the Salween–Mekong divide with the Mekong–Yangtze divide (Plate V), the climatic difference being emphasized by the very different appearance of the peaks in the two cases, those on the Mekong–Salween divide being pyramids, showing clearly the curve of water-erosion, while the Mekong–Yangtze divide is crowned by towers and square-faced buttresses, splintered out by the action of such 'dry' denuding agents as rapid and extreme alterations of temperature, frost, wind, and so on.

The conservative action of the snow blanket on the Mekong–Salween divide must also be taken into consideration, for not only is the snow-line at least 3,000 feet higher on the Mekong–Yangtze divide, but the snow above 14,000 feet on the latter ridge disappears in the spring long before it does from the same altitude on the former, and similarly the Mekong–Yangtze divide is still bare in the autumn long after the Mekong–Salween divide is covered up. Yet these two divides are only 20 miles apart as the crow flies.

Hence, while the Mekong–Salween divide is protected against weathering, there is also available a much greater quantity of water for purposes of transport, so that we do not find here those vast screes which are such a characteristic feature of the Mekong–Yangtze ridge. (Plate V.)

Such differences of climate, of course, cause a marked difference in the vegetation of the two ridges which in turn has its effect on the rocks, partly conservative, partly destructive; but apart from the mere appearance so produced, this is not of great importance to us just now. It will suffice to say that while the rainy Mekong–Salween divide is richly carpeted with plants as high as the snow-line, the scree-clad Mekong–Yangtze divide presents an expanse of semi-desert for the last two thousand feet or so below the snow-line.

As regards the rocks exposed in this region, they may be broadly classed under three heads: (1) limestone, (2) a coarse-grained grey granite, and (3) various metamorphic rocks, though, so far as my experience goes, never with a schistose structure; but whereas similar rocks, limestone, granite, and metamorphic, are common to all three valleys, there is considerable divergence between the two great divides (each of which I crossed by three passes), the Mekong–Salween being capped by igneous rocks and the Mekong–Yangtze by limestone, which readily lends itself to splintering. The region is doubtless rich in minerals, and I have on one occasion climbed a mountain which seemed to consist almost entirely of some metalliferous ore.

We will now pass on to consider an important point in connexion with the Mekong-Yangtze divide, namely, the evidence for previous glaciation.

I have mentioned two snow mountains on this divide, one of which I saw very clearly, though I did not visit it; but the glaciers are

certainly retreating, their bottle-nosed snouts being already some distance from the terminal moraines. Other evidence is derived from the 'hanging' valleys which descend immediately from the watershed and their peculiar 'tread and riser' structure, the valley floor ascending in a series of long abrupt steps to higher levels, each platform being the receptacle for a small lake occupying a rock-basin, one of which is shown in the photograph (Fig. 4, p. 151). Sometimes as many as five such lakes may occur in one valley, but usually there are fewer. Finally, we have the huge accumulations of angular rock fragments at the heads of the cirques, some of which at least are probably parts of old moraines. Of perched blocks and striæ, however, I saw no sign, though I do not attach much importance to that, for the climate is now all against their preservation.

Now it is evident that if the Mekong–Yangtze divide received as heavy a rainfall as does the Mekong–Salween divide there would be glaciers on the former where none now exist, so that the disappearance of the glaciers may be ascribed to a diminution of the rainfall. Why, then, has the rainfall become less? Evidently because it has been gradually cut off by the ranges to the west thrusting themselves up higher and higher till at last they form effective rain-screens. Nor is this all. Aneroid readings taken at different points in the beds of all three rivers show that the Yangtze flows at an average level of about a thousand feet above the Mekong, and the latter about the same height above the Salween, indicating a general western tilt of the country as it were, which within recent geological times has probably been in a condition of considerable instability; nor, indeed, are earthquakes rare, slight tremors being, I believe, frequent, which may help to account for the number of landslips, while hot springs issue from the base of every range. Such a tilt might easily cause a cracking of the crust, suggesting that these rivers really break through the rim of the Tibetan plateau along lines of weakness (fissures) or faults; but without believing for a moment that they have themselves carved out the deep gutters where they now flow, there is evidence, particularly in the Mekong gorges, for a very considerable amount of spade-work—for instance, pot-holes and ancient river cliffs now many feet above the highest flood-mark.

The crumpling and tilting of the rocks shows how the country has been pounded this way and that, but the general appearance points to a lateral pressure acting from the west (such as might be occasioned by a slight sliding motion of the main Himalayan axis eastwards), squeezing the belt of country up against an unyielding barrier in western China (supplied by the main east and west axis of uplift, separating the two great river systems of China), thus gradually raising the Mekong–Salween divide to its present considerable elevation, and so cutting off the rain supply of the older easternmost ridge—that remarkable freak of nature, the Mekong–Yangtze divide.

[The Editor is greatly indebted to the Syndics of the University Press, Cambridge, for permission to use the illustrations in this paper, which are reproduced from Mr. F. Kingdon Ward's forthcoming work entitled *The Land of the Blue Poppy: Travels of a Naturalist in Tibet.*]

III.—The Raised Beach of North Devon: its relation to others and to Palæolithic Man.

By Henry Dewey, F.G.S., H.M. Geological Survey.

WHILE mapping the Upper Devonian and Carboniferous Rocks in North Devon I took the opportunity of examining the raised beach of Barnstaple Bay and the deposits resting upon it. As a result of my observations I found that the sequence of these deposits is identical bed for bed with that of Cornwall, South Wales, and Southern Ireland, except that in place of the Boulder-clay there is in North Devon a bed of clay with striated stones which may not be of glacial origin. The position of the Boulder-clay over the ancient head, however, corresponds with the position of the bed of glaciated stones and indicates the infra-Glacial age of the 'head'. The fact that the 'head' is contemporaneous with 'Coombe Rock' has been held by all geologists familiar with the subject. It is a fact of first-class importance with regard to the relationship of man to the Glacial period, for it proves that man existed before these Boulder-clays were deposited. The evidence is inferential and supplied by the occurrence of Palæolithic implements of Le Moustier type in the Coombe Rock of Southern England and France. Granting, then, that the Le Moustier period is infra-Glacial, it remains to be seen to what Palæolithic period the raised beach belongs. We will proceed to consider the evidence available up to date, commencing with a brief account of the raised beach of North Devon.

North Devon.

From Morthoe to Westward Ho the raised beach can be recognized, intermittently notching the cliffs and forming a shelf some ten to fifteen feet above sea-level. It also extends inland as a flat terrace to Croyde village, and up the valley of the Taw towards Barnstaple. It has formed the subject of many contributions to geological literature, and a detailed account is therefore not required. A few localities will be selected where the sequence of deposits is well exposed, and short accounts of these will be given.

Between Croyde Sand and Saunton Down it is especially clear. In a road cutting and cliff sections in front of Down End House the sequence is readily recognized. The raised beach lies on a shelf and is covered by a variable thickness of current-bedded sand. Lying on this sand is a deposit of 'head' with a bed of large rounded stones resting on it, the top of this bed being 65 feet above O.D. The sands consist of alternate layers of hard and soft rock, the hard rock forming cornices with hollows beneath whence the soft sand has been eroded. The sand is shelly, containing numerous flakes and fragments and some whole tests of mollusca. Prestwich collected the following species[1]: *Helix virgata*, Da Costa, *H. cantiana*, Mont., *Bulimus ventricosus*, Drap., and quotes Gwyn Jeffreys, who remarks, "The *Bulimus* is a South European species, its most northern habitat being the south-west coast of France. The *Helices* are of species still living in the district." The fauna is warm temperate. The raised

[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 284, 1892.

beach consists of pebbles of slate, hard sandstone, vein-quartz, quartzite, and chalk-flints. Among the beach stones the familiar boulder of red granite lies on the raised beach platform. It resembles a gneissose granite from near Cruinard Bay, Ross-shire; other boulders are found near by which appear to have travelled from the West of Scotland.[1]

If these boulders are from Scotland (and they are certainly not derived from the West of England) it is difficult to assign any agency other than ice as their transporters. If ice-borne the seas of Scotland were Arctic and those of Southern England cold.

We have, then, the following sequence of deposits corresponding with a sequence of climates—

Bed of rounded stones (?).
Head (?).
Cemented sand (warm temperate).
Raised beach, with boulders (cold).

The climatic conditions in which the bed of large stones was deposited is not indicated at this locality, but is suggested by a similar deposit near Fremington.

On the west side of Fremington Pill a low cliff is covered by beach stones and 'head', with a bed of clay and stones resting on top. Some of these stones bear deep scratches, are flat, with one side smooth and the other rough, while others are smooth both sides. The striæ are roughly parallel to one another, and each is an elongated wedge trenching the stone and ending abruptly at its widest part. The clay in which they rest is brownish and loamy. They closely resemble striated stones from glacial till, and had they occurred in a glaciated district would be accepted as of glacial origin. But as there is a doubt as to the age of the clay it may be objected that the striæ were produced by some agency other than ice. The evidence for their glacial origin is, however, as strong as that adduced for the glacial origin of the Palæozoic tills, which is generally, though not unanimously, accepted by geologists.

A bed of clay in the immediate neighbourhood of the section has long been worked for the 'Barum' ware. It is a fine, smooth, mottled clay and contains large boulders. One of them is a hypersthene andesite resembling the tholeite of Loch Craignish, Argyllshire, while another is a granophyre.[1] The clay was therefore deposited under such conditions as would permit large erratic boulders to be dropped in it. It may be Boulder-clay as Maw [2] thought possible, and if so supports the view of the glacial origin of the striated stones. The railway cutting a few yards north of the section described shows current-bedded sand resting on the raised beach and itself covered with 'head'. Hence the sequence in descending order is—

Bed of clay, with striated stones and boulders (? Arctic).
Head.
Cemented sand (warm temperate).
Raised beach (cold).

[1] Proc. Geol. Assoc., vol. xxi, p. 429, 1910.
[2] Quart. Journ. Geol. Soc., vol. xx, p. 445.

Cornwall and South Devon.

The striking resemblance between these beds and those of North Cornwall led me to re-examine a fine section at Trebetheric Point, opposite Padstow. At this locality a thick bed of boulders consisting of quartz, greenstone, elvan, quartzite, flint, and hard grit rests partly on 'head' and partly on, and in hollows in, the cemented sands. The sands contain marine fossils such as limpet, mussel, and crab. While the underlying beach is preserved in patches only, the raised beach platform is conspicuous in the adjoining bay and on both sides of the estuary of the River Camel. The sequence of deposits is identical with those in North Devon, and persists in some degree all round the coasts of Cornwall and South Devon. The raised beaches of the West of England were admirably described by Ussher and others, so that further description is not necessary. It should, though, be mentioned that Reid[1] discovered an important section of raised beach at 65 feet above O.D. This is in Penlee Quarry, near Mousehole, on the east of Land's End.

Mr. Barrow[2] also made an important discovery in the Isles of Scilly, where a bed of glacially striated stones overlies 'head' and raised beach. And, what is of even greater consequence, he correlated this glacial deposit with the 'Limon' or Loess of the coast of Brittany, pointing out the identity of the succession seen in Brittany and Cornwall. This is important in relation to the question of the age of the raised beach, for, as will presently be shown, the 'Loess' ranges from St. Acheul to Le Moustier in the Palæolithic Series. From the accounts given it is evident that the same sequence of deposition occurred along the coasts of the whole of Cornwall and Devon. Moreover, it includes deposits formed under varying climatic conditions ranging from cold, if not Arctic, at the commencement of the raised beach phase, through warm temperate, when the sands were deposited, to a second cold period whose incoming is marked by the 'head' and its maximum by the bed of striated stones. Such faunal evidence as we possess confirms this order of events.

Glamorgan and Southern Ireland.

We may next inquire how far this sequence extended into neighbouring regions, namely Glamorgan and Southern Ireland on the one hand and the south coast of England on the other. To take Glamorgan first, we know from the observations of Prestwich,[3] Falconer,[3] Tiddeman,[4] Strahan,[5] and Leach[6] that the deposits overlying the raised beach in Glamorganshire are in descending order—

Recent head.
Boulder-clay.
Ancient head.
Blown sand (often cemented into sand-rock), with breccia.
Raised beach, with erratics.

[1] *Geology of the Land's End* (Mem. Geol. Surv.), p. 75.
[2] *Geology of the Isles of Scilly* (Mem. Geol. Surv.), pp. 21–31.
[3] Quart. Journ. Geol. Soc., vol. xlviii, p. 263, 1892.
[4] Rep. Brit. Assoc., 1900, p. 760.
[5] *Geology of South Wales Coalfield* (Mem. Geol. Surv.), pt. viii, p. 127, 1907. GEOL. MAG., 1911, p. 462.

If this succession be compared with that obtaining in Cornwall and Devon its close similarity is at once seen. In Glamorgan it is the more striking on account of the presence of true glacial till overlying the ancient 'head'. This till, therefore, represents the bed of striated stones and the boulder bed of Devon and Cornwall, and supplies strong evidence of the sequence of climates in Western Britain. The faunal evidence is entirely confirmatory. This is supplied for the most part from the mammalian deposits of the Gower Caves. In considering the relationship of these deposits to those of the contiguous raised beach Dr. Strahan[1] states of Falconer's conclusion that "granted his contention that the marine sands of the caves belong to the raised beach, and that the breccia associated with the marine sands corresponds to the breccia associated with the raised beach, it follows that the mammalian remains found in those deposits were placed there before the deposition of the boulder-clay".

The fauna described by Falconer is a mixed one, but contains mammalia indicative of a warm temperate climate. These are *Elephas antiquus*, *Rhinoceros leptorhinus*, *Hippopotamus major*, *Felis leo*, and others. Moreover, it is a fauna which is found in association with Palæolithic implements of the Chelles stage of culture. On the Continent the fauna associated with Chellean palæoliths is always a warm temperate or southern one; but in England northern animals are found with the southern ones. As we shall see later, the southern forms drop out of the fauna associated with a later stage of Palæolithic culture belonging to a period of advancing cold. In other words, the northern animals could survive a temperate climate, while the southern ones were either killed or forced to migrate on the approach of the cold.

It is important to assess the value of this evidence rightly so as not to overrate its significance. Taking Falconer's list of mammalia, the following significant species are referred to their several periods in the vertical columns:—

Gower Caves.	Pliocene.	Pleistocene.		
		—	Chelles.	Le Moustier.
Ursus spelæus . . .	×	×		
Mustela putorius (Polecat) .	—	×		
Lutra vulgaris (Otter) .	×	×		
Hyæna crocuta . . .	×	×		
Rhinoceros leptorhinus .	×	×	×	—
Rh. tichorhinus . .	?	×	×	×
Elephas antiquus . .	×	×	×	—
E. primigenius . . .	?	×	×	×
Sus scrofa	×	×	×	×

From the list[2] it will be seen that the fauna agrees more with the Chelles period than with either the Pliocene or Le Moustier. Prestwich

[1] *Geology of South Wales Coalfield* (Mem. Geol. Surv.), pt. viii, p. 127, 1907.
[2] E. T. Newton, in *Vertebrata of the Pliocene Deposits* (Mem. Geol. Surv., 1891).

compared the deposits in which these remains were found with the cemented sands overlying the raised beach south of the Bristol Channel, and concluded that they were synchronous, and that the animals of the caves formed an assemblage which was "the last one of the Pleistocene fauna with the exception of that of the Rubble Drift[1] or head". Hence the sequence in Glamorgan in relation to Palæolithic man is as follows:—

Recent head.
Boulder-clay (glacial).
Ancient head (Le Moustier and advancing cold).
Cave sands, etc. (Chelles, warm temperate).
Raised beach (cold).

In the South of Ireland Wright & Muff (Maufe)[2] recognized the same sequence at many localities, but two Boulder-clays overlie the head in superposition. The succession is therefore continuous from Eastern Devon to the south-west of Ireland. If we compare it with the one recognized on the coasts of Southern England we find it persists as far east as Folkestone. We may note in reference to climatic conditions that a fauna was found in the 'ancient head' of Cawsand Bay near Plymouth, which includes *Elephas primigenius* and *Hyæna*, while in a fissure near Plymouth these two forms were associated with *Rhinoceros tichorhinus*, *Rh. megarhinus*, *Cervus tarandus*, and *Bos primigenius*—forms which are characteristic of the 'head' further east.

Southern England.

The raised beach deposits of the South of England have long attracted attention, and have formed the subject of many contributions to geological literature. The chief observers are Mantell, Godwin-Austen, Prestwich, and Reid. In most cases where the beach is preserved the sequence is curtailed, but instances are not wanting where the several stages are recognizable. Thus we have—

3. Coombe Rock or head.
2. Clay or sands (temperate).
1. Raised beach.

3. All observers agree in regarding the Coombe Rock and head as being equivalent to one another, and there is no valid evidence to the contrary. The Coombe Rock has a tolerably rich fauna and one indicative of a cold climate. Moreover, it possesses a type of palæolithic implement by which its place in the Palæolithic sequence can be identified. I refer to the well-known Le Moustier type. These have been found abundantly in Coombe Rock at several localities, and at two overlying raised beach, namely at Sangatte near Calais and at Portslade near Brighton, where the rock included a palæolith approaching the St. Acheul type. The associated fauna includes *Elephas primigenius*, *Hippopotamus*, *Rhinoceros tichorhinus*, *Cervus tarandus*, *C. elaphus*, *Sus scrofa*, *Equus caballus*, *Bos*, *Hyæna*, etc. Reid and others have called attention to the glacial character of the

[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 305, 1892.
[2] Sci. Proc. Roy. Dublin Soc., N.S., vol. x, pt. ii, No. 25, p. 250, 1904.

deposit, which received its name from Dr. Mantell, who first described its occurrence at Brighton.

2. Underlying Coombe Rock at Selsea Promontory is an interesting series of deposits described by Reid.[1] First is a floor with stranded erratic blocks, one deeply striated, and many of foreign origin, apparently associated with a bed of clay containing a fauna and flora of Arctic species, which in turn is covered by a loam with no Arctic but many warm temperate forms.

1. The raised beach platform is strewn over with boulders of rock that have travelled far from their source. These include granites, gneisses, porphyries, and many other varieties of igneous rocks which have been described by Prestwich, Bonney, and others. Prestwich considered that they were in part derived from Scandinavia, Central Germany, and the Ardennes, and had been carried by ice southwards and stranded on the shore of the South of England. He therefore inferred that the Straits of Dover were then in existence.

That this ice was not due to the advance of a glacial episode but rather to the retreat of one is evident from the fauna of the raised beach. Of this Prestwich says[2]: "Of the total of sixty-four species (of mollusca) only thirty-nine are common to the glacial drifts of the North of England and Wales. There is the absence also . . . of such northern shells as *Astarte borealis*, *Leda pernula*, *Fusus islandicus*, *Natica grænlandia*, and others common in the glacial drift. The raised beach mollusca agree therefore pretty closely with the molluscan fauna now living in the British seas."

We are now in a position to compare the raised beach deposits and their faunas of the several coasts described previously, and to consider the sequence of events which led to their formation. To make the comparison readily intelligible the following tables are arranged:—

Climatic Conditions.	South of England.	Cornwall and Devon.	Glamorgan.	South Ireland.
Glacial . .	—	Bed of boulders and striated stones	Boulder-clay	Boulder-clay
Advancing cold	Coombe Rock	Head	Head	Head
Warm temperate	Beds of loam (in places)	Current-bedded sands—cemented	Current-bedded sand—cave deposits	Current-bedded sands
Waning cold	Glacial erratics	Glacial erratics	Glacial erratics	Glacial erratics
	Raised beach	Raised beach	Raised beach	Raised beach
Glacial . .	—	—	—	—

From an examination of this table we may say that there can be no doubt as to the identity of the sequence over the whole of the southern parts of Great Britain and Ireland. Granting this, then, there remains to be considered the relation of Palæolithic man to the several episodes indicated by the deposits. The evidence given so

[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 344, 1892. [2] Ibid., p. 263.

far is that a fauna closely related to that found with Chellean man occurs above the raised beach of Glamorganshire and below the 'head'. No Chellean palæoliths, however, have so far been found with this fauna, and so a doubt remains. But there can be no question as to its temperate character. The 'head' has yielded a fauna which is distinctive of Le Moustier times. Implements of Le Moustier type have been found in association with it in Coombe Rock both in England and France. The 'head' is therefore of Le Moustier period, in part at any rate, and this succeeds the supposed Chelles fauna of Gower.

Inland Localities.

We may now turn to the evidence supplied by deposits containing these palæoliths at inland localities. Perhaps no better district could be found where such Palæolithic deposits occur than the Thames Valley. We will, therefore, briefly consider the gravels of the Thames Valley in relation to Palæolithic man.

Since the Chalky Boulder-clay was deposited the Thames has eroded a wide channel during a succession of periods of activity alternating with long periods of rest. The result is a series of terraces at various heights above its present level. The highest of these has been termed the 100 foot terrace, and it rests upon Chalky Boulder-clay. The terrace is composed mainly of gravel containing an abundance of unworn Palæolithic implements of Chelles type, associated with remains of mammalia. Hence the Chellean period is later than the Chalky Boulder-clay. In making this statement reliance has not been placed upon the evidence derived from the Thames Valley alone, but also upon the known fact that wherever Chellean implements are found in an area of Chalky Boulder-clay they are always later than that deposit. The following instances will suffice to verify the statement. At Biddenham,[1] in Bedfordshire, the River Ouse has cut a valley 60 feet deep through Boulder-clay, and in its gravels palæoliths of Chelles type occur abundantly. In the classic localities of Suffolk[2] palæoliths of both Chelles and St. Acheul type occur in deposits overlying the Chalky Boulder-clay; while at Hoxne[3] the well-known section shows an infilled valley cut in Boulder-clay with St. Acheul implements in its upper gravels. The 100 foot terrace of the Thames is therefore Chellean and post-Chalky Boulder-clay. After its deposition uplift occurred with rejuvenescence of the river and its tributaries, which led to the formation of another terrace after the river had cut down its channel some 40 feet; this is the 50 foot terrace. Mr. A. M. Bell[4] has described from the gravels of this terrace at Wolvercote, in Oxfordshire, palæoliths of late St. Acheul or Le Moustier type. These are figured by Sollas[5] in *Science Progress*, and are associated with the

[1] J. Prestwich, Quart. Journ. Geol. Soc., vol. xvii, pp. 366–7, 1861.
[2] W. Allen Sturge, Proc. Prehist. Soc. E. Anglia, vol. i, pt. i, p. 43, 1912.
[3] C. Reid, "Relation of Palæolithic Man to the Glacial Epoch": Rep. Brit. Assoc., 1896, pp. 1–13.
[4] Quart. Journ. Geol. Soc., vol. lx, pp. 120–30, 1904.
[5] *Science Progress*, No. 15, 1910, p. 383.

'mammoth' fauna. Lower down stream, near Gravesend, a tributary has cut through the 100 foot gravels of the main river a valley some 40 feet deep, which is partially infilled with Coombe Rock. In this deposit many thousands of palæoliths have been found. They are identical with the 'Levallois flakes' of French authors, and occur much as they were left by their manufacturers before the downrush of Coombe Rock overwhelmed them. The evidence derived, then, from the Thames Valley is that after the Chalky Boulder-clay had been deposited the Thames cut a deep valley in several stages. The highest of these contains (1) a fauna indicating a warm temperate climate, and (2) Chelles palæoliths. After a period of uplift another terrace was cut in which animals of a cold climate are found in association with Le Moustier palæoliths, St. Acheul man living in the interim. Expressed in a tabular form we have the following sequence:—

Le Moustier period = Coombe Rock } (advancing cold).
St. Acheul period }
Chelles period (temperate).
Chalky Boulder-clay (Arctic).

This sequence of climates is identical with that indicated by the raised beach deposits, but to make it clear the several stages are shown in the following table—

	Palæolithic Period.	River Thames.	Raised Beaches.
Arctic	—	Ponders End deposits	Boulder-clay
Advancing cold	Le Moustier	Combe Rock / 50 ft. terrace gravels	Head
Warm temperate	St. Acheul / Chelles / Strépy	100 ft. terrace gravels	Cemented sands and cave sands
Retreating cold	—	—	Erratics of raised beach
Arctic	—	Chalky Boulder-clay	—

Conclusions.

1. That the deposits overlying the raised beaches were accumulated during a period of variable climate, being Arctic at first, then ameliorating to warm temperate, and finally returning to Arctic.

2. During the inter-Arctic period early Palæolithic man lived. He is later than the Chalky Boulder-clay and raised beach and earlier than the Boulder-clay of Glamorgan and Southern Ireland.

3. These conclusions accord with those of Continental authors, a brief summary of which is appended.

Summary of Conclusions of Continental Observers.

Professor Commont[1] has worked out the relations of the valley deposits of the River Somme to the stages of culture of Palæolithic

[1] "Les Gisements paléolithiques d'Abbeville," Excursion de la Société géologique du Nord et de la Faculté des Sciences de Lille, à Abbeville, le 11 Juin, 1910; and "Comparaison des Limons Belges et Etrangers," Ann. Soc. géol. Belg., tom. xxxix, 1912.

Climatic Conditions.	Thames Valley.	Eastern England.	Southern and Western Britain, raised beach deposits.	Penck and Brückner.	Prof. Boule.	Prof. Commont, Somme Valley.	Dr. Obermaier.
Arctic	Ponders End deposits	Purple Boulder-clay. 'Contorted Drift.'	Boulder-clay of Glamorgan and Boulder Beds of Cornwall and Devon.	Würm Moränen.			Le Moustier.
Advancing cold	Coombe Rock (Le Moustier), 50 ft. terrace gravels, uplift.	Brickearth of Mildenhall (Le Moustier).	Coombe Rock and Head (Le Moustier).	Niederterrassen Schotter, Jüngerer Loess (Le Moustier).	Late Loess (Le Moustier).	Late Loess (Le Moustier).	Late Loess, post third-glacial terrace of River Garonne.
Cold (?)	St. Acheul.	St. Acheul of Warren Hill Gravels.			St. Acheul, post third-glacial.	St. Acheul Early Loess.	St. Acheul.
Warm temperate	100 ft. terrace gravels, Chelles, Strépy.	Chelles of Warren Hill Gravels.	Warm temperate fauna and flora in clays and sands.			30 metre terrace of Somme (Chelles).	
Retreating cold	Uplift	—	Boulders on raised beach platform.	—		—	
Arctic	Chalky Boulder-clay, Plateau Gravels (Southern Drift).	Chalky Boulder-clay.	—	Riss Moränen.			
Warm temperate	—	Interglacial Sands.		Hochterrassen Schotter, Älterer Loess (St. Acheul).			
Arctic	—	Contorted Till, Cromer, etc.	—	Mindel Moränen, Jüngerer Deckenschotter. Günz Moränen, Älterer Deckenschotter.			

man. He finds that a terrace 30 metres above the bed of the river is covered with a sequence of gravels, sands, and the younger Loess which contain a fauna including *Elephas antiquus*, Hippopotamus, Horse, and the ancestor of *E. primigenius*. Along with these remains implements of Chelles type are found in abundance. Another terrace, 20 metres below this, is overlain by similar deposits, but the Palæolithic implements contained in these are later and include late Chelles (Chelléen évolué) and St. Acheul types. Both these terraces are covered with a younger Loess full of implements of Le Moustier type.

Penck & Brückner[1] consider that the younger Loess (Le Moustier) passes under the moraines of the fourth glacial episode. They thus agree with the conclusions of Professor Commont, but differ from him and from Professors Boule and Obermaier in placing the St. Acheul period in the second interglacial period. Professor Boule speaks of the discovery of St. Acheul palæoliths in the moraines of the third glacial episode; and Obermaier records them from the 55 metres terrace of the River Garonne, which he correlates with moraines of the third glacial episode.

These conclusions are shown in the subjoined table, where they are compared with the evidence derived from a study of the Palæolithic and glacial deposits of the southern parts of Great Britain. A very close agreement is seen to obtain among the European deposits of different localities, associated with the remains of Palæolithic man: an agreement which strengthens the evidence as to the age of the raised beaches of Southern England and Wales.

IV.—The Division of the Upper Chalk.

By A. J. Jukes-Browne, F.R.S., F.G.S.

THE Geological Magazine for February contained a lengthy criticism by Mr. R. M. Brydone of my article on the Recognition of Two Stages in the Upper Chalk, in the volume for last year. It is certainly curious that he should set himself the task of adverse criticism in such a voluminous fashion when he acknowledges at the outset that he sympathizes with my proposal. It appears, however, that he is dissatisfied with my reference to his work, and that he doubts the reliability of my lists of fossils from the new zones of *Offaster pilula* and *Actinocamax quadratus*.

The first is a personal question, and the facts are these: While I was collecting information about the zones of the Upper Chalk in Germany and France, Mr. Brydone wrote to me (October 3, 1911) saying that he proposed to make a new zone in Hampshire and Sussex by separating the lower part of the old zone of *A. quadratus* under a new name, and retaining a restricted zone of *A. quadratus* for the upper part. He and Mr. Griffith had already divided the old zone into three subzones, and he proposed to unite the two lower subzones into a zone of *O. pilula*, asking if I approved the use of that fossil as an index in spite of its being very rare in the lowest beds.

[1] *Die Alpen im Eiszeitalter*, vol. i, p. 112, 1901–9.

I replied in the affirmative and pointed out that the establishment of such a zone would bring our zonal arrangement into better accord with that of Germany, where a zone of *Scaphites binodosus* (containing *A. granulatus*) had been recognized as separate from the overlying zone of *A. quadratus*.

I am surprised that Mr. Brydone should profess to have some doubt about my intention to endorse his proposal and to accept his establishment of a new zone of *O. pilula* in Hampshire. What else could I intend when I stated that in Table III "the separate records of the zones of *O. pilula* and *A. quadratus* are based on those given by Messrs. Griffith and Brydone", to whose publication I had previously referred?

I did not "quote" from Mr. Brydone's letters nor mention any of the particulars which they conveyed, for that would have been unfair and discourteous; yet he complains that I ignored "the new grounds on which the proposal was based". The new zone was simply the union of two previously defined subzones, and it sufficed for my purpose to record his intention. How can there possibly be anything unfair in that?

He also thinks it was "hardly fair" to have written that the line at the top of the zone of *O. pilula* "has not yet been accurately determined in England or France", when I was aware that he had determined it in Hampshire. I admit that my meaning would have been more accurately expressed if I had written that the line had not been determined anywhere in the North of France, nor anywhere in England except in Hants. I present my apologies to Mr. Brydone for appearing to ignore his delimitation of the two zones in Hampshire, but I think most readers must have seen that I was thinking of the large areas over which the line of separation had not been determined, and for which records of the distribution of species were not yet available.

This brings us to the root of all Mr. Brydone's subsequent criticisms, and that is the value of *A. granulatus* as a zonal guide. His first remark is that the zone of *O. pilula* does not appear as such in all my tables, and that *A. granulatus* is introduced as if it were an equally good index to the zone as *O. pilula*. He feels certain that I intended "to lay it down that the ranges of *A. granulatus* (upwards from the *Marsupites* zone) and of *A. quadratus* (below the *Bel. mucronata* zone) corresponded with the two divisions of the old zone of *A. quadratus*".

He is, however, mistaken; I did not intend to make such an assumption, for in Table III I indicated the occasional occurrence of *A. quadratus* in the zone of *O. pilula*, where *granulatus* is the prevalent species. What I did assume was that *A. granulatus* did not occur in the restricted zone of *A. quadratus*, and I have yet to learn that it does. Mr. Brydone is at great pains to point out his own mistakes, and to explain that his own record of *A. granulatus* in the Hampshire zone of *O. pilula* is not reliable, but he does not state that he has found *A. granulatus* in the restricted zone of *A. quadratus*, either in Hampshire or Sussex.

I compiled my tables from the most authentic records accessible at the time, and those were the lists published by Mr. Rowe and by

Mr. Brydone himself. It seems that *A. granulatus* is a rare fossil in Hants and Wilts, but that does not prevent it from being a useful guide elsewhere, and Mr. Rowe's experience, as stated in his successive studies of the cliff-sections, is that it always occurs in the lower half of the old '*quadratus* zone' and does not range to the top of that zone, where *quadratus* usually occurs. Does Mr. Brydone mean to deny this? if so, let him say so and prove it, but he has no right to find fault with me for compiling lists in accordance with what has hitherto been regarded as an established fact.

The only published record of *A. granulatus* in the highest part of the zone is that for which I am responsible, as mentioned by Mr. Brydone, viz. in a quarry at Bramford, near Ipswich, where *Belemnitella mucronata* was afterwards found. That determination was made in 1902 and I cannot remember what the specimen was like, but I should not now like to maintain that it was *granulatus* without a second examination of it. The quarry may possibly expose the junction of the zones of *A. quadratus* and *B. mucronata*.

We come next to the Yorkshire Chalk, and I am told that I had no right to assume that the Yorkshire cliffs do not include any chalk of the restricted zone of *A. quadratus*. I have undoubtedly assumed that all the chalk in these cliffs and most of that inland belongs to the equivalent of the new zone of *O. pilula*, but I did not do so solely because true *A. quadratus* had not been found in the Sewerby cliffs. I relied on the positive facts (1) that *A. granulatus* is abundant throughout the exposed portion of the zone, and (2) that the thickness exposed in the cliffs is only 177 feet, whereas the total thickness of the whole zone of *A. quadratus* (so-called) must be about 400 feet.

The only place where a true *A. quadratus* has been found is the White Hill Quarry, No. 27 of Mr. Rowe's list and map, situate north of Bridlington and about 200 feet above the sea. An inspection of the map above mentioned will show that if 177 feet of chalk come into the Sewerby cliffs there must be some 340 feet of chalk between the basal outcrop of the zone and White Hill Quarry. Further, as Mr. Brydone has himself pointed out, the mere presence of *A. quadratus* does not itself prove that the restricted zone of that fossil has been reached. Hence the White Hill pit may still be within the limits of the lower zone, and, as Mr. Stather informs me that *S. binodosus* is fairly common in this pit, such a position seems very probable, for in Germany *S. binodosus* is only found in the 'granulaten kalk', and not in the German zone of *A. quadratus*.

Relying, therefore, on the association of *A. granulatus* and *O. pilula*, as well as on the absence of *A. quadratus*, throughout the Sewerby, Bessingby, and Carnaby areas, I felt justified in regarding this Yorkshire zone of *A. granulatus* as the equivalent of the German zone of *S. binodosus* and of Mr. Brydone's zone of *O. pilula*. If there is really any difference between the Yorkshire and the Hampshire zones, it is not (as Mr. Brydone suggests) that some of his higher zone may come into the Yorkshire cliffs, but that the Yorkshire zone of *A. granulatus* represents a larger portion of the old zone of *A. quadratus* than his zone of *O. pilula* does in Hampshire.

With respect to Sussex I relied on the published records, according to which *O. pilula* is common at intervals throughout the 170 feet exposed in the cliffs between Seaford and Brighton, while *A. granulatus* occurs through at least the lower 150 feet, where no true *A. granulatus* had been found. Moreover, when Mr. Brydone wrote to me in October, 1911, he said that he had found there was in Hampshire a marked break in the middle of the ancient zone of *A. quadratus*, and that "so far as is known *A. quadratus* does not range below it in Hants or Sussex". Since then, however, he appears to have obtained fresh evidence, and has found in Sussex specimens which he "*expects* to prove that there also *A. quadratus* ranged down into the upper division of the zone of *O. pilula*".

When I compiled my tables I had no reason to suppose that the restricted zone of *A. quadratus* came into the Sussex cliffs, and consequently I entered both *Inoceramus pinniformis* and *I. tuberculatus* as referable to the zone of *O. pilula*. When Mr. Brydone has published his fresh investigation of the Sussex coast-section, and has described the exact position of his restricted zone of *A. quadratus* in it, the precise location of these *Inocerami* will be of importance. The greater part of this higher zone must certainly be above all the Brighton chalk, and can only be found in the more western part of Sussex.

While I resent criticism that seems to be of a captious nature I assure Mr. Brydone and other readers that I welcome any fresh information and any definite corrections of the records in the tables which I compiled. The delimitation of the two zones in question has not yet been accomplished through the South of England nor in the North of France, and consequently my tables are a first attempt to show the change of fauna that seems to occur at about this horizon. Without essaying such a tabulation it would have been impossible to compare the zonal distribution in England with that which has so far been recorded in France and Germany.

With regard to Belgium Mr. Brydone makes a statement which is inaccurate. He says I have tabulated *A. verus*, *A. quadratus*, and *B. mucronata* as having "absolutely distinct ranges in Belgium", and thinks it "dangerous to tabulate the ranges of *A. verus* and *B. mucronata* as separated by two whole zones". I have not done so, and if he will look again at Table II he will see that both *A. quadratus* and *B. mucronata* are entered in the fifth column (zone of *A. quadratus*). I did not include *A. verus* because de Grossouvre in 1902 had expressed a doubt of its actual occurrence in the Craie de Triviéres, which represents the zone of *A. quadratus*. Possibly I should have accepted M. Rutot's record in spite of de Grossouvre's doubt, but Mr. Brydone knows that *A. verus* is very rarely found above the *Marsupites* zone, and in his recently published *Stratigraphy of the Chalk of Hants* he records one from the *quadratus* zone of Hampshire, remarking that "it is believed to be unique at that horizon for England". On the other hand, I wonder if the *B. mucronata* recorded from Triviéres can really be *B. lanceolata*, a form or species which does not seem to have been recognized in Belgium or France, but which is known to occur in the *quadratus* zone in England.

Finally, I would point out that the main object of my article is likely to be lost sight of in a controversy about the precise line of division between two zones and the inclusion of certain beds and certain fossils in the one or the other or both. I wish to concentrate attention on the main question, and on this we are happily all agreed, that it is desirable to divide the old zone of *A. quadratus* into two distinct zones, a lower and an upper. Future research must determine whether the two zones in the south are approximately coterminous with the two similar zones in the north or not, and whether the difference between the two faunas is as great in England as it seems to be in Germany.

REVIEWS.

I.—The Origin of the Himalayan Folding.

A MEMOIR recently published in India by Colonel S. G. Burrard, C.S.I., F.R.S.,[1] suggests an explanation of the Himalayan folds which geologists cannot afford to pass in silence, as his geodetic work points to conclusions that are at variance with the generally expressed view regarding the immediate cause of overthrusting in such folded ranges. The commonly accepted mental picture of the Himalayan folds depicts the strata as pushed over by great tangential thrusts from the north, the movement being resisted by the stable and ancient *Horst* forming the Indian Peninsula.

Colonel Burrard's results suggest that this view of the mechanism of Himalayan folding is inconsistent with the fact that, parallel to the general fold axis, along the southern foot of the range, and extending for about 15 miles outside the visible foot of the hills, there is a band which is characterized by an extraordinary deficiency in gravity. The observations so far made show that this band is especially sharp and abruptly marked on its northern margin, that is along the foot of the range, and that the deficiency in gravity gradually diminishes towards the south. The gravity values are those that might be expected if we had an empty fissure of about 6 miles deep, or a partially filled cavity of very much greater depth.

Colonel Burrard insists that the deficiency is altogether too great to be due to a simple synclinal depression filled with light alluvium, and he points out that, whatever be its nature, one cannot conceive of a band of low gravity being caused by the thrusting of a mass of rock against the peninsular *Horst*. He is thus forced to adopt a complete reversal of the accepted mechanical system of overthrust-folding, and to contemplate the existence of a deep-seated fissure opening out by a northerly creep of the sub-crust, while the overlying sedimentary carpet becomes puckered and wrinkled to accommodate itself to its shortened base. These wrinkles form the Himalayan ranges, the southerly-directed overthrust-faults and folds being due, not to a positive pushing over from the north of the superficial film of rock, but to a pulling back of the deep-seated support.

[1] *On the Origin of the Himalaya Mountains* (Professional Paper No. 12, 1912, Survey of India, Calcutta).

There is no doubt that the observed *facts* cannot be challenged; they are not limited to a small number of uncorrected observations, and are of the same order of magnitude outside the foot of the Eastern, the Central, and the Western Himalaya. The corrections made for the subterranean partial compensation of the Himalayan protuberance, and even for the assumed disturbing influences of the distant major features of geomorphology leave the relative local variations in gravity still pronounced and unexplained.

The results quoted by Colonel Burrard as *observed* deflections of the plumb-line have been obtained by deducting the geodetic values of latitude and longitude from the astronomical values, the geodetic values being computed by triangulation based on the Clark-Bessel spheroid.[1] The deflections that ought to be expected from topographical inequalities are based on the assumption that the superficial crust has an average specific gravity of 2·8, and that inequalities are not compensated by corresponding variations in density below the crust. The deflections mentioned as calculated on the assumption of complete compensation are based on the results published by J. F. Hayford,[2] who assumes the existence of general compensation for surface inequalities uniformly distributed to a depth of 113·7 kilometres.

A single example will be sufficient to illustrate the results obtained for traverses made from the Himalaya to the plains. Kurseong (26° 52′; 88° 18′)[3] in the Darjeeling district at an elevation of 4,428 feet, Siliguri (26° 42′; 88° 27′)[3] immediately at the foot of the range, standing 401 feet above the sea-level, and Jalpaiguri (26° 31′; 88° 47′)[3] 13 miles out on the plains at an elevation of only 280 feet, are not far from a meridional line. Between Kurseong and Siliguri the deflection of the plumb-line ought to change by 19″ if the mountains were not isostatically compensated at all, and the difference should be only 11″ if Hayford's hypothesis of perfect compensation were applicable, but the observed difference is as much as 28″. Similarly, between Siliguri and Jalpaiguri the difference should be 7″ according to calculations from uncompensated topography, and only 4″ according to Hayford's theory, while the observed difference is 17″. Thus, for the whole distance of 25 miles, between Kurseong in the Outer Himalaya and Jalpaiguri on the plains, the difference in deflection is 45″ instead of 26″, as it would be without mountain compensation, and 15″, as it should be according to Hayford's hypothesis.

As long as geologists were content to believe in a cooling and shrinking core, we had a satisfactory mental picture of a collapsing and wrinkling skin. But this explanation was found to overreach itself, the folds in the coat being so flagrantly generous that if flattened out the Earth would have a cover several sizes too large for itself. However, the old theory received adventitious aid from the

[1] S. G. Burrard, *Phil. Trans.*, A, vol. 205, p. 218, 1905.

[2] *The figure of the Earth and Isostasy from measurements in the United States*, Washington, 1909.

[3] As the greatest arc of North latitude in India is less than the smallest arc of East longitude, the values stated in the usual order cannot be confused.

supposition that the crust has received much igneous material from inside, has expanded by hydration, and has otherwise grown. But there still remained, as Dutton pointed out in framing his theory of isostasy, qualitative as well as quantitative difficulties: the superficial overthrusting of folded ranges was still not explained with perfect satisfaction.

A new suggestion of the kind now made by Colonel Burrard thus deserves more than casual comparison with the data; for there are, it seems to me, many geological and physical considerations that debatably seem to fall into line with this new theory. Among these reference might be made in this short communication to—

1. The numerous tension faults, which show a general east to west trend in the northern part of the Indian Peninsula, and have affected in succession the pre-Carboniferous Vindhyan strata and the Permo-Carboniferous Lower Gondwana beds, while newer fissures of the same kind became the channels through which the Deccan Trap was erupted at the end of the Mesozoic era (cf. Mem. Geol. Surv. Ind., vols. vi, pt. ii; xv; xxi, pt. iii; xxiv, pt. i; and xxxi, pt. i). The general trend of these tension faults is significantly parallel to that of Colonel Burrard's assumed 'rift' and associated earth-folds.

2. The welling-up of a great granitic core behind (that is, to the north) of the band of exceptionally low gravity, and on the southern edge of the geosyncline which was slowly fed with marine sediment during much of the Palæozoic and most of the Mesozoic era.

3. The possibility that, if there has been at all an appreciable cooling of the earth since the close of Mesozoic times, such cooling would result in the contraction and splitting of what Colonel Burrard calls the sub-crust, while there would be little or no appreciable reduction in the temperature and size of the great central core.

4. Such loss of heat would be most rapid in the geosynclinal belts on which our great fold-ranges have always risen. This suggestion substantially agrees with that made by Dr. J. Milne from the distribution of earthquakes (33rd Report, Seismological Committee, Brit. Assoc., 1912).

5. Mr. R. D. Oldham has shown that the megaseisms—earth-shaking quakes—probably originate at great depths, and are but accidentally and rarely connected with the visible superficial faults in the seismic regions (Quart. Journ. Geol. Soc., lxv, 1–20, 1909).

6. The symmetrical character of those geanticlines which show overthrusting in opposite directions, does not conveniently illustrate even the worn-out textbook idea of a superficial crust collapsing and crumpling on a shrinking core.

The 'rift' postulated by Colonel Burrard is altogether different in depth and character to the fore-deep of Professor Suess, who regards the peninsula as a stable block against which the Himalayan mass is being rolled; this would not account for a band of deficient gravity outside and beyond the visible hills.

Up to last year ideas regarding the production of rifts at great depths were inhibited by the conclusions of C. R. Van Hise and L. M. Hoskins regarding the comparatively shallow depths at which the strongest rocks become plastic under the superincumbent

earth-pressure; but Professor F. D. Adams (Journ. Geol., 1912, pp. 97–118) has shown experimentally that empty cavities may exist in a rock like granite under pressure equivalent to depths of at least 11 miles, and that they may exist at still greater depths if filled with liquids. Colonel Burrard's assumption, therefore, does not appear to be impossible from this point of view.

In 1904 the Rev. O. Fisher[1] partially anticipated the results now obtained by the Survey of India by calculating the deflections of the plumb-line in North India which would follow from his theory of mountain compensation by a 'root' extending to a depth of about 29 miles. The variations now observed are, however, more violent than those expected by Mr. Fisher, for the northerly deflections of the plumb-line decrease to zero at a distance of about 15 instead of over 60 miles from the visible foot of the hills. It will be interesting now to obtain a comparison of the observed deflections with those calculated by Mr. Fisher, whose theory, however, does not otherwise march, like that now offered, in consonance with the growing belief in a solid earth.

THOMAS H. HOLLAND.

II.—INDEX TO THE STRATIGRAPHY OF NORTH AMERICA. By BAILEY WILLIS. Accompanied by a Geological Map of North America, dated 1911. 4to; pp. 894, with 19 text-illustrations. Washington: United States Geological Survey, Professional Paper 71, 1912.

THIS elaborate volume, although designed to explain the geological map which accompanies it, will be a permanent and invaluable work of reference on the North American formations. In turning over the pages we are reminded of a letter by Dr. F. A. Bather on "Stratigraphical Names", printed in the GEOLOGICAL MAGAZINE for March, 1912, p. 141. Therein he calls attention to the number of names for formations and periods, remarking that his card-index to them extends to a thickness of more than two yards; and he comments on the inconvenience of the application of the same topographic names to formations of different ages in various countries. In the present work we find a Hastings Series of Pre-Cambrian age; and such names as Lebanon Limestone, Athens Shale, and Canaan Dolomite applied to Ordovician strata in America. In that country, where so many British and other European names have been given to towns and villages, it would be difficult to avoid the application of some of them to local sedimentary divisions; and we find among

[1] *Phil. Mag.*, January, 1904, p. 14. According to an anonymous review recently published in *Nature* of February 27 (p. 704), Col. Burrard is said to have overlooked this paper by Mr. Fisher. He, however, answered it in the same volume of the *Phil. Mag.* (p. 292); but the Editor of *Nature*, although he is aware that Col. Burrard is in India and cannot thus reply for some weeks, has refused to correct his statement on the grounds that the remark "applies with perfect correctness to the memoir reviewed". In other words, the reviewer is able to distinguish between the knowledge possessed by Col. Burrard and that possessed by the writer of Col. Burrard's memoir! The existence of this uncanny ability suggests a clue to the origin of the legend that the Editor of *Nature* sometimes appears to confuse himself with the Author of it.

other familiar names, those of Bedford Oolitic Limestone, Mansfield Sandstone, and Elgin Sandstone applied to Carboniferous strata in the United States. Nevertheless, where such formations are of minor or purely local interest the matter is not very serious. In the work before us perhaps the majority of local geological divisions have a distinctly American savour; such as the Cusseta Sand, the Cussewago Sandstone, Swearinger Slates, Sacramento formation, Perry Sandstone, Sillery formation, Great Smoky Conglomerate, and Birdseye Limestone, to say nothing of other and more familiar names derived appropriately from native American localities.

Turning now to the geological map, we find it to comprise four large sheets, on the scale of 1 : 5,000,000 or about 1 inch to 80 miles. It includes the north-western corner of South America and extends therefrom to the Bering Strait, the Parry Islands, and Greenland, with insets showing the Windward and the Aleutian Islands. Each map has its separate series of index-tablets, desirable because in some areas the systems have been mapped in more detail than in others where they are undifferentiated. Moreover, there are some differences in the classifications adopted by the Surveys of Canada, Mexico, and the United States, while the chronological limits of formations naturally vary. Printed on one sheet of the map there is a general series of colour tablets, which shows at a glance the scheme of classification, the larger groupings being Archeozoic, Proterozoic, Paleozoic, Mesozoic, and Cenozoic, together with Pre-Cambrian and Post-Cambrian Intrusive rocks, and Tertiary and later Effusive rocks. It should be remembered that Professor Lapworth used the term Proterozoic or Protozoic for Cambrian, Ordovician, and Silurian. In the work before us Proterozoic is applied to the Pre-Cambrian, or in other words to Algonkian, which includes Huronian and Keweenawan. It is eminently satisfactory to find the names for the geological systems in harmony with those in general use in Europe, such as Cambrian, Ordovician, Silurian, etc.

The immense advance in knowledge of the geology of North America during the past sixty or seventy years is manifest when we compare this new map with the area coloured in Lyell's "Geological Map of the United States, Canada, etc., compiled from the State Surveys of the United States and other sources", and published by John Murray in 1845. Very little of Canada and but a small region west of the Mississippi were then coloured geologically. The present map has been compiled in co-operation with the Geological Survey of Canada and the Geological Institute of Mexico, under the supervision of Mr. Willis and Mr. George W. Stose.

Intended for use as a wall-map, as well as for local reference, the colours have been carefully selected, and the guiding principles in their adoption are set forth in an interesting and instructive manner. The International scheme of colours was found unsuitable; in North America, for instance, few distinctive tablets are required for the Mesozoic divisions as compared with those of the newer and older formations. The main systems are depicted, sometimes locally divided as in the case of the Carboniferous into Mississippian and Pennsylvanian, sometimes united as in the cases of Eocene and

Oligocene, Cambrian and Lower Ordovician. It may be remarked that the general appearance of the map is excellent, and it owes much to the careful preparation and drawing of the geological lines by Mr. H. S. Selden, who has utilized the published maps and important contributions from many geologists, whose labours and assistance are fully and cordially acknowledged. The map is divided by parallels at intervals of 4° and by meridians at intervals of 6°, and the enclosed spaces are designated by letters and numbers. These index divisions are utilized throughout the text to denote areas described, so that reference to the map is greatly facilitated.

Further, a number of sketch-maps are given in the text to show the distribution of igneous rocks, of Pre-Cambrian, Silurian, Devonian, Upper and Lower Cretaceous, and other main divisions.

In the text, as remarked by Mr. Bailey Willis, "The material selected comprises discussions of stratigraphy, some citations of fossils, and some views on correlation. The aim has been to state stratigraphic facts as fully as the data available or the scope of the work permit and to include as much as space allows relating to faunas and correlation."

This is but a bald statement of contents. The work, in fact, is a compendium of North American geology, with a bibliography of the stratigraphy containing references to 953 published books and papers and a capital index. All formations and local divisions in all districts on the mainland and in islands from the Pre-Cambrian to the Pliocene are described so far as possible. The Quaternary deposits are not dealt with, but on the map there is one tablet for alluvium, lacustrine and desert-basin deposits, Glacial Drift (in small part only), and beach, dune, and marine deposits of the Atlantic and Gulf coasts; and these are shown only where the underlying formations are completely concealed.

III.—The Geology of Dartmoor. By Clement Reid, G. Barrow, R. L. Sherlock, D. A. MacAlister, H. Dewey, and C. N. Bromehead; with contributions by J. S. Flett and W. A. E. Ussher. 8vo; pp. vi, 102, with 2 plates and 17 text-illustrations. Printed for His Majesty's Stationery Office, 1912. Price 2*s.* 3*d.*

THE area described in this memoir includes the central and greater part of Dartmoor. Cranmere Pool, a peaty hollow, noted as being in the centre of the region from which the Dart and other rivers radiate, is on the northern margin of the map; Sheepstor and the famous Burrator reservoir for the water-supply of Plymouth, Ditsworthy Warren, and Buckfastleigh Moor occur along the southern margin of the map. This large tract of granite is full of interest from scenic, antiquarian, and geologic points of view. Apart from the tors, the many standing stones, hut circles, tumuli, and even the old stone tramway made for the conveyance of granite from Haytor Quarries, are objects that are well calculated to arouse the attention of visitors.

Although upland peat-mosses are said to occupy most of the land, above 1,600 feet, to the north-west of the Princetown and Moreton-hampstead road, only the alluvial or 'basin-peats' are coloured on

the map, the approximate limits of the upland or hill-peat being indicated by dotted lines, not easy to distinguish at a glance, so that a text-map of the peat-covered areas would have been useful.

Most of the granite is coarse-grained with large crystals of pale felspar, but some small areas of fine-grained granite, as well as a few felsite or elvan dykes, are distinguished by colour on the map. The bordering ground is occupied by the Middle Devonian Limestone of Ashburton, by Upper Devonian slates with thin limestones, and by Culm Measures.

These Carboniferous rocks are subdivided into—

Shale and Grit	Upper Culm (?).
Radiolarian Chert . . .	Lower Culm.
Shale, Limestone, and Grit	

The Culm Measures are regarded as "the equivalents of the lower part of the Millstone Grit, and perhaps of the upper part of the Carboniferous Limestone", and it is considered doubtful whether any of the strata in the district are later than the Millstone Grit. Here we may ask, "What about the Pendleside Series or Upper Limestone Shales?"[1]

In the picturesque region of Holne Chase, as pointed out by Mr. Barrow, the Devonian is found to overlie the Carboniferous, the junction being a plane of overthrust.

Volcanic outbursts took place both in Devonian and Carboniferous times, and in the former case the rocks described by Champernowne as schalsteins (Ashprington Series) overlie the Ashburton Limestone. Although mostly "sheared and altered into schalsteins", in some instances the rocks, as observed by Dr. Flett and Mr. Dewey, "are sufficiently well-preserved to show that they had originally the characteristic pillow-structure of spilites." Pillow-lava also occurs around Marytavy, in close association with the Radiolarian Chert of the Culm Measures. Intrusive sheets of diabase or allied rock are also described as occurring both in the Devonian and Carboniferous strata. Two small dykes of Mica Trap, probably of Permian age, are likewise noted.

Petrographical descriptions are given of the granite and of the aureole of thermometamorphism surrounding it. Much of the granite is disintegrated and decomposed at the surface, so that it can be dug to a considerable depth with pick and shovel. No china-clay, however, has been found in the area, although it occurs and is worked in the country to the south. It is considered that the "granite probably forms a gigantic laccolite or intruded lake of molten rock, of which the upper surface was no great height above the present surface of the moor". The discussion raised some twenty-five years ago by Mr. Ussher, and carried on by Mr. R. N. Worth, General McMahon, and Mr. A. R. Hunt, is not dealt with, but the Bibliography contains the titles of their papers. To these should have been added the address on "The Geology of Devon", by W. H. Hudleston (Trans. Devon. Assoc. for 1889, and GEOL. MAG.,

[1] See Ussher, in *Geology in the Field*, Jubilee Vol. Geol. Assoc., 1910, p. 886.

1889, pp. 560–3). One other paper only do we miss from the Bibliography, and that is by D. Mackintosh, entitled "Railway Geology, No. 1, from Exeter to Newton-Bushell and Moretonhampstead" (Geol. Mag., 1867, p. 390). He gave some account of the small 'rock-basins' of Dartmoor, as also did Ormerod in his paper of 1859, noted in the Bibliography. Their observations might have been mentioned in the text.

There is an interesting chapter on "Tertiary and Drift", in which is discussed the origin of the present physical features. These include the plateaus (or relics of them) at elevations of about 800 and 1,000 feet; and the ravines, such as that of Lydford. Attention is drawn to the ancient stream-tin deposits, and to the agents that may have been at work during the Glacial period, leading to snow-slope screes, etc. It is observed (p. 62) that "taken as a whole the Dartmoor peat is rapidly wasting away", but locally there are indications of active growth, and it would appear that in the tracts above 1,600 feet the conditions of mist and cloud would be favourable as noted (p. 1). Further, it is remarked that "The peat-mosses, just now of little economic importance, will be worked again as fuel becomes more expensive and the better methods now in use are applied". At the same time, when the question of water-supply is considered (p. 89), the value of the covering of peat in storing water is pointed out, and it is questioned "whether it is advisable to allow the peat to be removed, unless at the same time Dartmoor is planted with trees". Among the metalliferous deposits are ores of tin, copper, arsenic, lead, silver, manganese, zinc, and iron, but there are few mines in work at the present time. "Tin, or perhaps mixed tin and copper-ore, was probably worked in Devon and Cornwall as far back as the bronze age," and "The manufacture of pewter in the third century probably led to alluvial working for stream-tin on Dartmoor". Particulars and sections of various mines are given. Ochre and umber are obtained from open works at Ashburton.

From the foregoing remarks it will be evident how much there is of scientific and practical interest in this well-written and carefully edited memoir.

Geological Survey Memoir.

IV.—Records of London Wells. By G. Barrow and L. J. Wills. 8vo; pp. iv, 213, with 3 plates and 4 text-illustrations. Printed for His Majesty's Stationery Office, 1913. Price 4*s.* 6*d.*

THIS work is a highly important supplement to the information gathered during many years, chiefly by Mr. Whitaker, and printed in Geological Survey Memoirs and other publications. The general lowering of the water-level in the Chalk, on which the supplies from the London wells and borings almost wholly depend, was discussed so long ago as 1851 by Prestwich, and has been more or less a matter of concern ever since. As remarked by the Director in his Preface, recent observations show that "Not only is the fall greater than was anticipated, but it has been taking place at an increasing rate during the last ten years". The need, therefore, of

a special inquiry, not only into the causes of the depletion, but also of the unequal distribution of water in the Chalk of the London district, has become urgent; and the various matters are now discussed in a philosophic spirit by Mr. Barrow in part i, the introduction to this memoir.

The volume is divided into three parts, and we may conveniently commence by a brief description of the contents of parts ii and iii, which constitute the bulk of the memoir. Part ii (pp. 34–90) is a Catalogue of Published London Wells, the object being to record their precise sites, and to give details of supply and other information that in many instances had not previously been published. The actual records of the strata are not repeated, but some additional particulars relating to them are here and there inserted. The 6 in. London County map of the Ordnance Survey in the first place has been utilized to record the positions of the wells. Each sheet of the map has been divided in 2 in. squares with letters and numbers, and these sheets are deposited in the Geological Survey Office for public reference. By a series of abbreviations the data relating to each well are concisely noted in the memoir. They indicate where the record was published, the site of the well as marked on the 6 in. sheet, the elevation of the ground, the depth of well (shaft) and boring, diameter of bore, position of Chalk surface above or below Ordnance Datum, water-level, and yield of water in gallons per hour.

Part iii is a descriptive account (rather than list) of wells, mostly new, but a few previously published. Of most interest geologically are the records of the deep borings at Beckton Gasworks, East Ham; Chiswick; Southall; and Willesden (two). All of these five borings after penetrating the Gault entered rocks in all probability of Devonian or Old Red Sandstone age, at depths respectively of 975, 1,120½, 1,135, 1,098, and 1,153 feet from the surface. At Southall the strata contained fish-remains of Old Red Sandstone age. Saline waters were encountered in these old rocks at East Ham and at Willesden (Stonebridge Park). A brief account of the Palæozoic floor is given in the Introduction (part i). Among the records of the wells and borings no mention is made of Blackheath Beds, but they may be represented in the strata passed through at East Greenwich Portland Cement Works and at Shirley (pp. 113 and 203).

Part i (pp. 1–33), the readable portion of the memoir, is an essay mainly on the water-bearing capacity of the Chalk in different parts of the London District; and Mr. Barrow takes the opportunity of describing the methods of constructing the old and new wells and the headings in the Chalk. He points out how the water in the lower sandy portion of the Woolwich and Reading Beds, as well as that in the Thanet Sands (where present), may be directly connected with that in the Chalk. He discusses the character of the water obtained directly from the Thanet Sands at considerable depths, a matter dealt with by Mr. Whitaker in his *Geology of London*, 1889 (vol. i, p. 513), and more recently by Dr. J. C. Thresh, whose views were adversely criticised in *The Surveyor* for July 26, 1912. There is no doubt that the Thanet Sand water is mainly derived from that which enters the Chalk outcrop, and that it has undergone chemical

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changes that render it softer; but it is highly questionable whether the sodium-salts which it contains are derived from the preservation of original sea-water. The amount of sodium chloride has, however, been found to decrease in certain localities where pumping has been in progress for some time, and Mr. Barrow suggests that a part of the replaced calcium has passed into the form of a calcium-salt in the interstitial matter of the rocks.

Exceedingly important are his remarks on the relation of the water-supply in the Chalk to the geological structure. Not only are the effects of heavy loads of Eocene strata adverse to fissures and free circulation of water in the Chalk, but it is important to consider the undulations and faults in that formation. Thus the passage of water through the Chalk, apart from fissures, is dependent on the water-level, and is influenced by the lithological nature of the Chalk, and still more by the pressure of the head of water towards the margins of the basin. The consideration of these matters is greatly helped by two colour-printed maps prepared by Mr. Wills. One shows the contours in the underground water-surface or water-table of the London District for 1911; and the other shows the contours in the Pre-Tertiary Chalk surface, or, in other words, the height above or depth below Ordnance Datum at which the Chalk occurs where overlain by Eocene strata. Small maps are also inserted, for comparison, to show the underground water-contours in the London Chalk in 1878, between 1890 and 1900, and in 1911. Mr. Barrow is thus able to discuss the areas of maximum and minimum water-supply, and the causes for the distribution and local depletion. Moreover, the question of the drawing in of impure water from the valley gravels, where they directly overlie Thanet Sand and Chalk, and possibly of water from the Thames in certain low-lying localities, is engaging serious attention, as noted some few years ago by Mr. Clayton Beadle.

The effects of pumping carried out towards the margin of the London Basin are to decrease the head of water that would otherwise press towards the centre of the basin; moreover, the underground circulation is affected by the light or heavy loaded Eocene areas, as well as by the character of the Chalk itself. Mr. Barrow regards it as urgently necessary to raise once more the water-level in the London Basin, and suggests that much might be done by means of dumb-wells on the outskirts of the London District. Needless to say, his essay is one that will repay attentive study by all interested in the subject of water-supply from the Chalk.

V.—Brief Notices.

1. Union of South Africa: Mines Department.—We have received the Annual Reports for 1911 of the Geological Survey of the province of Transvaal (pt. iii, 1912, price 7*s*. 6*d*.). This volume contains a useful map, scale 1 inch to 30 miles, showing the areas surveyed up to the end of 1911. It may be mentioned that the report of the Director, Mr. H. Kynaston, is printed in Dutch as well as in English. The field-reports include one on "The Lower Witwatersrand System on the Central Rand", by Dr. E. T. Mellor,

and therein he has been able to adopt a definite classification and nomenclature for the strata, which should be applicable to the whole of the Witwatersrand area. The Director contributes a report on "The Geology of a portion of the Rustenburgh District, lying north of the Pilandsberg", and Dr. W. A. Humphrey describes "The Geology of the Pilandsberg", a remarkable igneous complex which is considered to mark an important centre of eruption of the elæolite-syenite magma. In addition to the field-work in the Transvaal an area of 342 square miles was mapped in Natal near Vryheid by Dr. Humphrey, who contributes "Notes on a traverse through parts of the Vryheid District and Zululand". There is also a short "Report on the Coal Resources of South Africa". The maps, sections, and pictorial illustrations in this volume are well executed and instructive.

2. Cainozoic Mollusca from South Africa.—The importance of careful collecting has received further emphasis from the report of Mr. R. Bullen Newton on some Cainozoic shells from South Africa (Records of the Albany Museum, vol. ii, No. 5, February, 1913, pp. 315–52—not 251–88 as in author's copies—pls. xvii–xxiv). The author describes a number of marine mollusca from the Cainozoic deposits of South Africa which form part of the 'Alexandria Formation' of Professor Schwarz, and are attributed to a probable Mio-Pliocene horizon. Attention is drawn to the fact that this formation was originally considered as of Cretaceous age on account of the occurrence of *Melina* cf. *gaudichaudi* in the upper part of the Need's Camp Limestones near East London. This had previously been described as a Cretaceous shell by Mr. Henry Woods under the name of *Perna* sp. This form of *Melina*, however, is proved to exhibit affinities with a South American Miocene shell, while it occurs in other districts of South Africa where the Alexandria formation is exposed in association with forms of mollusca showing a late Tertiary facies. It is explained that the Need's Camp deposits, as first demonstrated by Dr. A. W. Rogers, consist of an upper and a lower series of limestones distant some two miles from each other. The upper or younger beds contain this Tertiary *Melina* cf. *gaudichaudi*, while the lower or older beds are characterized by Polyzoa, etc., of undoubted Cretaceous age.

The Bemrose collotypes from photographs by H. C. Herring, of the British Museum, are extremely good and deserve a word of praise. The combination of a good photograph and a good collotype leaves little to be desired in the illustration of fossil mollusca.—C. D. S.

3. Water-Supply Papers of the United States Geological Survey.—We have received Nos. 284, 289–91, 296, 298, and 304 of these papers, and they deal with the surface-waters of the St. Lawrence River, the Colorado, the Great Basin, and the Sacramento River Basin, also with the waters of the Pacific Coast in California. Two of the papers constitute a gazetteer of the surface-waters of California. Of more geological interest is the paper, No. 294, entitled "An Intensive Study of the Water Resources of a part of Owens Valley, California", by Mr. Charles H. Lee, 1912. This valley lies in East Central California, and receives its water-supply from precipitation

on the eastern slope of the Sierra Nevada. It is an enclosed basin, so lined by impervious rock-formations that its ground-waters have practically no subterranean outlet. The only outlets for the water are afforded by evaporation from water-surfaces and damp soil and transpiration from vegetation. The alluvial material which forms the "valley fill" varies in size from large boulders to fine clay; and in arrangement it is partly mixed and partly in layers of well-assorted gravel, sand, and clay. It includes materials of the outwash slope and of the valley floor, the underground supply of water being obtained by percolation from precipitation on the surface, from stream channels, and irrigation. The surface area of the valley fill is reckoned to be 230 square miles, and its depth in places approaches 2,000 feet. Allowing an average depth of 1,000 feet, and having regard to the porosity of the material, it is estimated that nearly eleven cubic miles of water are stored. It is, however, remarked that the amount to be derived for practical purposes could not exceed that of the natural loss or overflow.

4. Building and Ornamental Stones of Canada.—Parts i and ii of a Report on these subjects has been prepared by Dr. W. A. Parks and issued in one volume (Ottawa, 1912, pp. 376). The first part consists of a general introduction to the subject, dealing with the chemical, physical, and geological features of building-stones, and with the methods of quarrying, testing, and preparing stone for the market. The materials include granite and other igneous rocks, sandstones, limestones, and slates. Many illustrations of quarries and of machinery are given. The second part consists of a systematic description of the building and ornamental stones which occur in that part of Ontario lying south of the Ottawa and French Rivers. It is prefaced by an outline of the geology of Ontario. Full particulars are then given of the various building-stones and marbles, illustrated with views of edifices in which particular stones have been used, views of quarries, and maps. There are also a number of coloured plates of limestones, dolomites, and sundry marbles, including sodalite. This mineral, the blue variety of which is regarded as one of the most beautiful decorative stones in Canada, is practically confined to Ontario, inasmuch as it is not known to occur elsewhere in sufficient bulk to be of economic importance. It is found as segregations in a belt of nepheline syenite, and can be obtained in slabs up to 4 feet square. In composition, sodalite is a silicate of sodium and aluminium, in which some chlorine is present.

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 5, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "On Two Deep Borings at Calvert Station (North Buckinghamshire), and on the Palæozoic Floor north of the Thames." By Arthur

Morley Davies, A.R.C.S., D.Sc., F.G.S., and John Pringle, H.M. Geological Survey.

The two borings are about 370 yards apart in a due east-and-west direction. The eastern boring gives the following section:—

Altitude of surface = about 290 O.D.	Thickness in ft.	in.
Soil	4	0
Oxford Clay—*Ornatum* zone	93	3
Non-sequence.		
Forest Marble	38	9
Non-sequence.		
Great Oolite	59	6
Non-sequence.		
Chipping Norton Limestones	7	6
Non-sequence.		
Lias—Domerian, *Algovianum* zone to Charmouthian, *Jamesoni* zone	240	6
Unconformity.		
Lower Tremadoc—Shineton Shales	954	6
	1398	0

The Oxford Clay is represented by grey and blue clays, the lowest bed of which is a hard, tough, brownish clay full of broken shell-fragments; among the forms identified from it are *Cosmoceras sedgwicki* (Pratt) and *C. stutchburii*? (Pratt).

The Forest Marble consists mainly of grey and bluish-grey oolitic and earthy limestones, with grey, brown, and green clays at the base. An exceedingly bright bluish-green clay, 3 inches thick, is also present. The limestones are very fossiliferous, but the organisms are badly preserved.

The Great Oolite is represented by grey limestones and grey marly limestones, dark-grey sands, and clays. The highest member is correlated with the 'Cream Cheese' top of the Great Oolite in the Bicester cuttings. From the upper part of the section *Terebratula bathonica*, S. S. Buckman, was obtained; near the base there is a 2 foot band full of *Rhynchonella* and *Ostrea*. The section is compared with the Fritwell-Ardley section on the new railway from Ashendon to Aynho.

The Chipping Norton Limestones consist of a yellowish oolitic limestone and a grey sandy limestone, also markedly oolitic.

The Lias is represented by pale-grey shales with very little variation in character. Near the base is a limestone containing fragments of Palæozoic rocks and many fossils, of which the most abundant is *Zeilleria waterhousei* (Davidson), characteristic of the *Jamesoni* zone. This limestone also yielded a derived fragment of *Echioceras microdiscus* (Quenstedt), a *Raricostatum*-zone fossil.

In the western boring only, strata yielding inflammable gas were met with. Reasons are given for believing that these may have been Triassic. If not, they are probably Upper Palæozoic.

The Tremadocian shales resemble those of Shropshire; their dip varies from 40° to nearly 90°. They show interesting structures resulting from differential movement; at several horizons they yield well-preserved examples of *Clonograptus tenellus*, var. *callavei*

(Lapworth), and *Obolella* (?) aff. *salteri*, Holl. They are traversed by two sills of olivine-basalt. The uppermost 50 feet are stained red.

The following new reading of the Bletchley boring is proposed :—

	Feet.
Oxford Clay	192
Forest Marble	33
Lias (Charmouthian) . .	185

An attempt is made to express the depth of the Palæozoic floor by a contoured map, and its possible constitution and tectonic structure are discussed.

2. "On the Skeleton of *Ornithodesmus latidens*, an Ornithosaur from the Wealden Shales of Atherfield (Isle of Wight)." By Reginald Walter Hooley, F.G.S.

The bones were obtained from blocks recovered from the sea after being washed from a huge fall of the Wealden Shales. Portions of the skeleton missing in the Atherfield specimens are supplemented by bones in the British Museum (Natural History), No. R/176, upon which the late Professor H. G. Seeley founded the genus. There are remarkable peculiarities in the skull which isolate it from all known families, such as the presence of a sixth vacuity and a transposition of the jugal and quadratojugal in regard to the supra- and infra-temporal arcades. The jugal is excluded from the upper arch, and the jugal and quadratojugal from the lower, which is formed entirely by the quadrate. The orbits are placed far back in the skull, and the quadrate articulation is much in front of them. The occiput is concave. Teeth occur only at the extremity of the long muzzle; they are set close together, and those of the upper jaw interlock with those of the lower jaw. The notarium, the humerus, the decussation of the ulna by the radius, the sternum, and femur all show divergence from other types.

The wonderful preservation of the bones enables the mechanism of the skull, joints, and movements of the limbs to be described.

The paper deals with the morphology, and institutes comparisons with other types.

The evidence proves that it is necessary to form a new family, and that *Ornithodesmus* has descended from a sub-order which should include *Scaphognathus* and *Dimorphodon*. The author suggests the withdrawal of these two genera from the Rhamphorhynchidæ, and the formation of a new sub-order; and also that there are three entirely different phases of development shown in the skulls of the known Ornithosauria, which permit of their division into three sub-orders.

Measurements of the bones are given.

Annual General Meeting.

February 21, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The Reports of the Council and of the Library Committee were read. Of the 63 Fellows elected in 1912, 43 paid their admission fees before the end of that year, making, with 13 previously elected

Fellows, a total accession of 56 in the course of 1912. During the same period the losses by death, etc., amounted to 58 (6 more than in 1911), the actual decrease in the number of Fellows being, therefore, 2 (as compared with a decrease of 5 in 1911). The total number of Fellows on December 31, 1912, was 1,292.

The Balance-sheet for that year showed receipts to the amount of £3,417 15*s.* 9*d.* (excluding the balance of £475 11*s.* 10*d.* brought forward from 1911), and an expenditure of £3,252 5*s.* 6*d.*

Reports were communicated from the Director of the British Museum (Natural History) and from the Director of the Museum of Practical Geology, regarding the progress accomplished in the arrangement of the collections transferred to those Museums by the Society.

The List of Awards of the various Medals and Proceeds of Donation Funds in the gift of the Council was also read.

The Report of the Library Committee enumerated the extensive additions made during 1912 to the Society's Library, and alluded to the re-arrangement of the Library which is now in progress.

The Reports having been received, the President handed the Wollaston Medal, awarded to the Rev. Osmond Fisher, M.A., to Sir Archibald Geikie, K.C.B., Pres.R.S., for transmission to the recipient, addressing him as follows:—

Sir ARCHIBALD GEIKIE,—More than forty years ago, in my earliest struggles with the elements of geology, I received much kindly encouragement from my revered teacher and relative, Osmond Fisher. Twenty years later it was my pleasure to follow his footsteps, and to profit by the closest scrutiny of his work, in the Isle of Purbeck. It is now my privilege to request you to forward to him, in accordance with a unanimous vote, the highest award which it is in the power of the Council of the Geological Society of London to bestow—the Wollaston Medal.

I have referred especially to his work on the Purbeck Beds, because it is that with which I have the closest acquaintance. Written as long ago as 1856, his paper on that remarkable group of strata has formed the basis of all subsequent investigations; but no less masterly was his account of the Bracklesham Beds of the Isle of Wight Basin, which followed in 1862. The two together placed him at once in the ranks of those pioneer geologists who, self-trained in all branches of their science, laid the foundations of British stratigraphy.

It is probable, however, that the name of Osmond Fisher will dwell in the memory of posterity more especially as that of the author of the *Physics of the Earth's Crust*. First produced in 1881, that work was founded on geological reasoning and mathematical proof which it was within the power of few to appreciate. Its value, growing in recognition during the lapse of more than thirty years, is now acknowledged, and the book has taken rank as a classic on what is perhaps the most recondite subject which a geologist can be called on to investigate.

It is needless to refer in detail to the papers on a variety of other subjects with which Mr. Fisher has enriched geological literature, for they have already been mentioned from this chair on the occasion of the presentation to him of the Murchison Medal. But to what was then said I will now add that we are rejoiced to see him still maintaining his interest in current geological work at the great age of 95, and that it is a satisfaction to us to add this further proof of our appreciation of his labours.

Will you, therefore, be so good as to transmit this Wollaston Medal to Osmond Fisher as a recognition by the Council of the lasting value of his "researches concerning the mineral structure of the Earth".

Sir Archibald Geikie, in reply, said :—

Mr. President,—No duty at once more honourable and agreeable could be entrusted to a Fellow of this Society than to act as a deputy for one of the most venerable and esteemed of our colleagues and to receive on his behalf the Wollaston Medal, which has been awarded to him in recognition of the value and distinction of his contributions to geological science. I have been favoured with a short statement from Mr. Fisher, which I will now read :—

"It is indeed a most gratifying surprise to me that the Council of the Geological Society should have considered me worthy of their highest honour, the Wollaston Medal. At my great age (95) I shall not be able to attend and to offer my grateful thanks in person. I think that the Council must have formed a higher opinion of my merits than I have, but I must not quarrel with that. I once had as a pupil a scion of the Wollaston family. He was an entomologist, and wrote a learned work upon the insects of Madeira. He described the insect-remains which I found in Lexden brick-pit.

"I am thankful to say that I am still able to take an interest in our science. I am engaged at present in a mathematical investigation of the effect of an elevated plateau, like the Himalayan, when below the horizon of a station, in increasing gravity there. It will have to be taken account of in drawing conclusions from observations on gravity in the plains of India. My friend Davison is helping me with the arithmetic, in which I cannot trust myself. Arithmetic was not taught at Eton when I was there. I am afraid that the chief interest in my problem will be mathematical. In all problems of attraction hitherto the curvature of the earth's surface has been neglected. I have taken account of it, I believe, for the first time."

In receiving this Medal for transmission to our revered Associate, I should like to add an expression of my own indebtedness to the illuminating suggestiveness and clear presentation of his contributions to physical geology. It is astonishing and delightful to see him, at his advanced age, still full of mental alertness and enthusiasm, busy as ever in the continuation of the long series of mathematical investigations with which he has enriched geological literature. He has set to all of us a noble example of modest, earnest, and unwearied devotion to the cause of our favourite science. Let us trust that the brave veteran may not only live to complete the research on which he tells us that he is engaged, but prolong for years to come his sunny and beneficent old age.

The President then presented the Murchison Medal to Mr. George Barrow, F.G.S., addressing him in the following words :—

Mr. Barrow,—It is a great pleasure to me to hand to one who has been my colleague for many years a tribute paid by the Council of the Geological Society to a life spent in the furtherance of geological science.

In awarding to you the Murchison Medal they have borne in mind that you commenced your official career by investigations of a part of Yorkshire remarkable both for the development of Lower Mesozoic rocks and for its physical features, and by writing a terse and lucid account of it in the North Cleveland memoir. They remember, too, that after assisting in the mapping of the West Yorkshire dales, you proceeded to the Scottish Highlands, and that by there introducing modern petrographical methods you obtained results which have left a permanent mark in the literature on that fertile source of geological controversy. Your paper in 1893 on an Intrusion of Muscovite-Biotite Gneiss has taken high rank, not only as a storehouse of careful observations on the characters of igneous and metamorphic rocks, but as elucidating the problems connected with hypogene geology. It was followed by announcements of your discovery of chloritoid in Kincardineshire and of the possible occurrence of Silurian strata in Forfarshire ; while in 1904 you threw much light on the difficult question of the relationship of the Moine Gneisses of Perthshire to the metamorphic rocks of other parts of Scotland.

On your transference to Devon and Cornwall the experience which you had gained was utilized in unravelling the structure of that tormented region, and

in studying the phenomena presented by the metamorphic aureoles round the granitic intrusions. Here also your paper on the high-level platform of Bodmin Moor proved that more recent phenomena were not escaping your attention. At the present time the work upon which you are engaged in Warwickshire is already throwing much light on some obscure stratigraphy.

Will you allow me, as an old colleague who has had every opportunity of judging, to add my own testimony that your work, wherever you have been placed, has been characterized by that thoroughness and conscientiousness in the field which alone can lead to permanent advance in the interpretation of geological phenomena. On behalf of the Council I beg you to accept this Medal and Award.

Mr. Barrow, in reply, said:—

Mr. President,—I feel deeply the honour which the Society has conferred on me by the award of the Murchison Medal. I have spent many years working on those Highland rocks in which the founder of this Medal took so keen an interest. The Murchison Medal has now been awarded to several workers on these rocks, and as no two of us have come to the same conclusions, it is gratifying to feel that the Fellows of this Society can rely implicitly on the impartiality of its Council in its awards. I have to thank you very much for the kindly way in which you have spoken of my work; it is especially agreeable, as coming from an old colleague and the head of that branch of the service to which I belong, which makes it a special pleasure to receive the Medal from your hands.

In presenting the Lyell Medal to Mr. S. S. Buckman, F.G.S., the President addressed him as follows:—

Mr. Buckman,—The Lyell Medal is by custom associated more especially with palæontological research. It is, therefore, fittingly awarded to you in recognition of the conspicuous place which you hold among British palæontologists, as regards both your intimate knowledge of species and your philosophic treatment of your subject. While you are an eminent exponent of that school of thought and mode of study with which the name of Hyatt is associated, your own work exhibits a marked originality and independence of outlook. Moreover, not only is it pregnant with suggestive ideas, but it forms an example of pure scientific research having proved to be of value in practical application.

Your investigations on the generic relationships of the Jurassic Ammonites are the best example of your specialized labours. In a great monograph on the Ammonites of the Inferior Oolite Series, and in other works, you have sought to apply with precision the principles which underlie the correlations between ontogenetic and phylogenetic growth. Your research among the Brachiopods is no less illuminating as an example of the application of evolutionary principles; and, in dealing with the fossil forms, you have illustrated the production of similar morphic sequences in separate stocks and the frequency of homœomorphy.

The zonal method has been applied by you to stratigraphical problems with exceptional minuteness and accuracy. So great is your experience in handling difficult questions of zonal correlation that you have acquired powers of interpretation which seem almost instinctive.

From my own knowledge I can speak of the value of your services in revising collections in public museums, and in converting mere accumulations of fossils into orderly sequences, eminently instructive as regards both evolution of species and stratigraphical significance. It is my privilege to hand to you this Medal and Award in recognition of brilliant and original palæontological research.

Mr. Buckman, in reply, said:—

Mr. President,—It is with feelings of very great pleasure that I receive the unexpected honour of the Lyell Medal awarded to me by the Council; and when I listened to your kindly references to my work I felt that your recognition of its merits was far too flattering, especially when so much of what I hoped to accomplish still remains undone owing to certain causes. But it gives me

particular pleasure to receive this award from your hands, for you belong to a body of scientific men whose practical work in geological surveying enables them to judge the value of stratigraphical labours.

It is now thirty-two years since the Society did me the honour to accept a paper from my pen. My later work has followed that paper up, though in more detail in the nomenclature both of strata and of species. But my later work is guided by my interest in the study of evolution, good illustrative subjects being found among Ammonites and Brachiopoda. This stratigraphic and classificatory work was and is the necessary, if somewhat monotonous, spade-work for evolution; for it was useless to compile genealogies while the sequence of strata was unknown in detail, and while nomenclature included polyphyletic forms under the same designation.

Through attention to and insistence on the importance of apparently trivial details, the phenomenon of homœomorphy was discovered, and the reception accorded to homœomorphy has at any rate been cordial. But it involves a revision, almost a rewriting, of palæontology. Much of my earlier work I have revised; much of it I should like to rewrite.

Such spade-work finds perhaps its fullest expression in the publication *Yorkshire Type-Ammonites*; for the bed-rock of nomenclature must be an exact knowledge of types. And I cannot let this opportunity pass without acknowledging the debt which I owe to my enthusiastic collaborator, Mr. J. W. Tutcher, who combines an excellent geological knowledge with unrivalled photographic skill. His work has been the making of that publication.

To you, sir, and to the Council I tender my heartfelt thanks for an award which encourages me to continue my researches.

The President then presented the Bigsby Medal to Sir Thomas Henry Holland, K.C.I.E., addressing him in the following words:—

Sir THOMAS HOLLAND,—The Council have awarded to you the Bigsby Medal in recognition of the eminent services which you have rendered to geology, more especially during your tenure of office in India. Appointed to the Geological Survey of India in 1890, you proceeded to enrich the Records and other publications, not only with papers on petrological and other scientific questions, but with the discussion of problems more directly bearing on the welfare and safety of the inhabitants of India. Under your Directorship, from 1903 to 1909, the Geological Survey of India maintained its high reputation; while, at the same time, advantage was taken of your sagacity and extended geological experience to obtain your advice in the administration of Indian scientific affairs.

It is not possible for me to refer in detail to your published works. They range from petrology, mineralogy, stratigraphy, and seismology into the domain of geography, one of your latest papers having been devoted to an account of the remarkable dissemination of salt which can be effected by wind. But I may emphasize, in the words of the founder of this Medal, the fact that you are not too young to have done much, and that you are not too old for further work. It is the hope of the Council that you will continue for many years at home the eminently useful career which you have commenced so auspiciously in India.

Sir Thomas Holland replied as follows:—

I deeply appreciate the honour which has been conferred on me by the Council, as well as the generous terms in which you, sir, have referred to my work. Nothing could be more pleasing to a worker than to be enjoined by one's seniors to continue in work.

A glance over the list of my distinguished predecessors shows how abundantly each one subsequently fulfilled the intention of this award, and thus one's feelings of satisfaction become tinged with those of great responsibility. At the same time, when one realizes that the Council hitherto has never made a mistake in its selection of a recipient for the Bigsby Medal, this feeling of responsibility becomes again blended with that of hopeful ambition.

In so far as this honour is a recognition of work already done, I should like to make it known to the Council that my chief aims in India have been to

facilitate the work of my colleagues. No published work of my own has caused me more anxious care, or given me greater satisfaction, than the memoirs issued in the names of my colleagues on the Geological Survey of India; it was because of their abundantly loyal support that a measure of success followed my administration, and it is because this honour in effect recognizes their good work that it gives me peculiar pleasure.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Mr. William Wickham King, F.G.S., the President addressed him as follows:—

Mr. Wickham King,—The Council have awarded to you the Wollaston Fund, to mark more especially their appreciation of your researches on the Permian Conglomerates of the Lower Severn Basin. Probably no group of British deposits called more urgently for investigation than the red rocks of the Midlands. Their remarkable conglomerates, breccias, and calcareous bands offered problems of the greatest interest; while the stratigraphical sequence and correlation throughout the country called for reconsideration. Though the story is not yet fully told, your paper marked a notable advance in its elucidation; the Permian breccias of the Severn Valley are inseparably connected in men's minds with your name.

The Council are aware that you are engaged upon other problems connected with the district in which you have laboured to such advantage, and make this award, not only in recognition of what you have done, but in anticipation of equally good work to follow.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Mr. Ernest Edward Leslie Dixon, B.Sc., F.G.S., addressing him in the following words:—

Mr. Dixon,—The Murchison Fund has been awarded to you by the Council of our Society to mark their sense of the value of your detailed observations on the Carboniferous Limestone. Working in association with Dr. Vaughan, and armed with the knowledge which you had gained during your official survey of the region, you were able to combine detailed palæontological and stratigraphical observations in such a manner as to produce an exhaustive account of the varying geographical conditions under which the limestone of Gower came into existence. You have also provided us with an admirable account, founded in part upon your own observations, of the remarkable overfolds exhibited in the Pyrenees. May I be permitted to add, from my own knowledge of a colleague with whom I have long been associated, my testimony to your zeal and to that carefulness in field-work which leaves no stone unturned and no note unmade. The Council in making this award anticipate with confidence further results from your labours.

In presenting the Balance of the Proceeds of the Lyell Geological Fund to Mr. Llewellyn Treacher, F.G.S., the President addressed him as follows:—

Mr. Treacher,—The Council have awarded to you the Lyell Fund in recognition of the value of your contributions on the Chalk. In 1905, in association with Mr. Osborne White, you were able to add greatly to our knowledge of the fauna and zonal affinities of the Taplow phosphatic chalk. In the following year, with the same collaborator, you described some occurrences in Berkshire of phosphatic chalk not previously known, and also published the result of your joint investigations on the Upper Chalk of the western end of the London Basin, showing in detail the extent of the Tertiary transgression. While thus engaged you have not omitted to collect the relics which Neolithic and Palæolithic men have left in the Thames Valley. For my own part I take this opportunity of acknowledging the great utility of such observations as yours in the work of the Geological Survey. We look forward to the continuance of your researches.

The President then presented a Moiety of the Proceeds of the Barlow-Jameson Fund to Bernard Smith, M.A., addressing him as follows:—

Mr. SMITH.—In awarding to you a part of the Barlow-Jameson Fund the Council have borne in mind that our knowledge of the glacial phenomena of Black Combe is largely due to your researches. In your admirable account of that region every branch of the inquiry has received due consideration; but your description of channels now for the most part abandoned, though occupied during the Glacial Period by marginal streams or overflows, forms a special feature of your paper. In the course of your official work in Nottinghamshire you have made good use of your opportunities to study the remarkable skerry-bands of the Keuper Marl, and found reason to connect their formation with the variations of the seasons. Lower Palæozoic rocks also have engaged your attention in Ireland.

This award has been made in the expectation that you will continue the career so well begun, and will do yet more "for the advancement of geological science".

In handing the other Moiety of the Proceeds of the Barlow-Jameson Fund, awarded to John Brooke Scrivenor, M.A., to Mr. Clement Reid, F.R.S., for transmission to the recipient, the President addressed him in the following words:—

Mr. REID,—In the course of a rapid journey in Patagonia, Mr. Scrivenor found time to make observations on the sedimentary and igneous rocks and on the river-system of that country. From 1902, as a member of the staff of the Geological Survey, he was associated with you in Cornwall, and rendered valuable assistance in preparing the maps and memoirs illustrating the country around Newquay and the Land's End. In 1905 he was selected as Government Geologist in the Federated Malay States, and since his appointment has enriched our knowledge of that difficult region by papers on the mode of occurrence and mining of gold, tin, copper, and other ores, by descriptions of Archæan and igneous rocks, and by researches on the sedimentary sequence. Both in range of subject and in extent of travel he has distinguished himself as one of our leading exponents of the geology of the more distant parts of the Empire.

In transmitting to him a part of the Barlow-Jameson Fund, will you assure him that we at home watch with interest the work of our colleagues abroad, and will you express on our behalf the hope that he may long preserve the energy necessary for the prosecution of such arduous labours?

The President thereafter proceeded to read his Anniversary Address, giving Obituary Notices of several Foreign Members, Foreign Correspondents, and Fellows deceased since the last Annual Meeting, including Professor G. J. Brush (elected a Foreign Member in 1894); Professor F. Zirkel (el. 1880); Professor F. A. Forel (elected a Foreign Correspondent in 1910); Professor K. von Krustshov (el. 1895); Professor E. von Koken (el. 1900); Professor R. S. Tarr (el. 1909); J. Dickinson (elected a Fellow in 1842); Dr. R. H. Traquair (el. 1874); R. Bruce Foote (el. 1867); J. Parker (el. 1867); Captain A. W. Stiffe (el. 1874); Dr. J. Morison (el. 1887); W. H. Pickering (el. 1907); Sir Charles Whitehead (el. 1872); and Dr. J. S. Phené (el. 1887).

As the main object of his Address, the President discussed the form of that part of the Palæozoic platform which underlies the Secondary rocks of the South-East of England. Upwards of forty borings have been carried down to it, and have provided sufficient evidence for the construction of a contoured map of parts of it. Two regions are still

unknown, namely the southern counties and a tract extending north-westwards from the estuary of the Thames; but, between the two, contour-lines at 500, 1,000, and 1,500 feet below sea-level can be drawn for considerable distances. The form of the platform thus illustrated shows no connexion with its geological structure, so far as that is known, and may be attributed to planation, for the most part by marine action, and to warping by the post-Oligocene movements which produced the dominant structure of the South-East of England.

To illustrate the effect of these movements a second map is constructed, showing contour-lines in the base of the Gault at intervals of 500 feet, extending from 500 feet above the sea to 2,500 feet below it. The result is to give a comprehensive view of the warping undergone by the Upper Cretaceous and Tertiary rocks and of the magnitude of the movements. The height above sea-level to which the base of the Gault has been raised, and the depth below sea-level to which it has been depressed, can be estimated approximately at every point from the contouring. It thus becomes possible to see what corrections are necessary to restore the base of the Gault to horizontality, and thus to eliminate the effects of the post-Oligocene movements.

By making this correction in the first map, the Palæozoic platform is restored to the form that it possessed before those movements came into operation. A third map, thus constructed, shows that considerable changes were effected. A tract of high elevation clearly defines itself under London and near Harwich. On the northern and southern sides the contour-lines run with much regularity, and those on the south give evidence of a bold slope continuing downwards far in that direction. It appears that the London Syncline has come into existence in an area that was long one of elevation, and that the Wealden Anticline has been superimposed upon a region of depression.

It is further pointed out that, for a continuance of these investigations, we are dependent upon the making of borings for coal or water; but that no machinery has been created for the systematic registration of borings, notwithstanding the recommendation made in the Report of the Royal Commission on Coal Supplies. The information gained in a borehole may come to hand by chance, or it may be lost. Frequently no permanent record is kept of the site, diameter, or depth of boreholes.

It is noted with pleasure that a precise levelling is being carried out by the Ordnance Survey to replace the levelling made in 1841 to 1859, which was not of modern precision, and was recorded by marks which were not permanent. It is pointed out that in work of the precision contemplated factors of unknown value may have to be taken into account, such for example as earth-tides or the effect of the oceanic tide upon coastal regions, but more especially the variations in gravity which are known to exist, although they have never been systematically examined in the British Isles. Observations are in progress in India and in many foreign countries; but in our own country they ceased at a critical stage. The early observers in the middle of the last century became aware of the existence of the variations, and, while experimenting on the deflection of the plumb-line

caused by mountain-masses such as Schiehallion and Arthur's Seat, found reason to conclude that deflection was caused also by variations in the specific gravity of underground rocks.

There is some reason for believing that lines of equal gravity may have some connexion with magnetic 'ridge-lines'. It has been recently recommended that the Magnetic Survey of 1891 should be repeated. It is suggested that a Gravity Survey is equally desirable. The British Isles, in virtue both of their geographical position on the margin of the European Continent, and in virtue of the form and structure of the Palæozoic platform, appear to constitute a region eminently suited for such an investigation.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year :—

OFFICERS :—*President :* Aubrey Strahan, Sc.D., F.R.S. *Vice-Presidents :* Professor Edmund J. Garwood, M.A. ; Richard Dixon Oldham, F.R.S. ; Clement Reid, F.R.S., F.L.S. ; Professor W. W. Watts, Sc.D., M.Sc., F.R.S. *Secretaries :* A. Smith Woodward, LL.D., F.R.S. ; Herbert Henry Thomas, M.A., B.Sc. *Foreign Secretary :* Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S. *Treasurer :* Bedford McNeill, Assoc.R.S.M.

The other Members of COUNCIL elected were :—Henry A. Allen ; Henry Howe Bemrose, J.P., Sc.D. ; Professor Thomas George Bonney, Sc.D., LL.D., F.R.S. ; James Vincent Elsden, D.Sc. ; John William Evans, D.Sc., LL.B. ; William George Fearnsides, M.A. ; Professor Owen Thomas Jones, M.A., D.Sc. ; Herbert Lapworth, D.Sc., M.Inst.C.E. ; Horace W. Monckton, Treas.L.S. ; Edwin Tulley Newton, F.R.S. ; George Thurland Prior, M.A., D.Sc., F.R.S. ; Arthur Vaughan, M.A., D.Sc. ; William Whitaker, B.A., F.R.S. ; Rev. Henry Hoyte Winwood, M.A.

February 26, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read :—

1. "The Geology of Bardsey Island (Carnarvonshire)." By Charles Alfred Matley, D.Sc., F.G.S. ; with an Appendix on the Petrography by John Smith Flett, M.A., D.Sc., F.G.S.

Bardsey, an island a mile and three-quarters long, lies off the promontory of the Lleyn (Western Carnarvonshire), and forms the isolated extremity of the strip of pre-Cambrian rocks that borders the western coast of the Lleyn from Nevin south-westwards.

The rocks are principally gritty schistose slates, with many thin and some thick bands of grit, quartzite, and limestone ; and they contain an horizon of variolitic lava and tufaceous shale, which indicates that a volcanic episode took place during their formation. Sills of albite-diabase also occur, as well as one or more sills of a crushed granite.

The rocks have been subjected to intense earth-pressure acting mainly from the north-west, and are mostly in a cataclastic condition, the harder rocks being almost always torn up into lenticles. The beds are shown to be arranged on the whole in a number of isoclinal folds, complicated by overthrusting, shearing, and brecciation. Stages in the formation of crush conglomerates are described. From the nature of the brecciation and the comparatively small amount of mineral alteration that the beds have undergone, it is inferred that

the load of superincumbent rock at the time of the principal earth-movements was not great.

The rocks are correlated with the lower portion of the Llanbadrig Beds and with the Llanfair y'nghornwy Beds of Anglesey, and they agree also with their Anglesey representatives in the manner in which they have been affected by earth-movement.

Some post-movement dykes of olivine-dolerite occur, with a north-west to south-east trend. They are probably of Tertiary age.

Glacial striæ and boulders indicate that the island was invaded by a portion of the Irish Sea ice-sheet, which, after crossing Anglesey to the west of Red Wharf Bay in a south-westerly direction, was deflected in Carnarvon Bay and traversed Bardsey in a south-easterly direction. This direction is tentatively attributed to the pressure of ice radiating from Ireland.

There are doubtful indications of a post-Glacial raised beach at 18 to 20 feet O.D.

In an Appendix Dr. J. S. Flett describes the petrographical characters of the granites, the pillow-lavas and their tuffs, and the diabases.

2. "The Loch Awe Syncline (Argyllshire)." By Edward Battersby Bailey, B.A., F.G.S.

Mr. J. B. Hill's classification of the sedimentary schists of the district, into the Loch Awe Group above, and the Ardrishaig Group below, is accepted. So also is his reading of the Loch Awe Syncline. This syncline is a comparatively shallow trough, with well-marked fan-structure due to small-scale isoclinal folding, in which the limbs of the folds are vertical along the axial belt of the syncline, and inclined outwards on either side.

There are, however, two modifications of Mr. Hill's original interpretation, both of them already dealt with, in part, by Dr. B. N. Peach and the author in the Geological Survey memoir describing the southernmost portion of the region (Sheet 28). One of the proposed alterations is concerned with the numberless igneous rocks folded along with the sedimentary schists. Many of these are obvious intrusions; but some, as Dr. Peach showed in 1903, are certainly lavas. In the present paper Dr. Peach's volcanic zone is traced throughout the whole district, where it maintains a constant horizon in the Loch Awe Group. This brings us to the second suggested modification, affecting, as it does, details of the stratigraphy of the Loch Awe Group, for which the following sequence is proposed:—

Loch Avich Green Slates and Grits (volcanic rocks in the lower part).
Tayvallich Black Slates and Limestones (volcanic rocks throughout).
Crinan Grits and Quartzites.
Shira Limestone, constituting a passage-zone down into the Ardrishaig Phyllites.

Attention is drawn to evidence, already published, that the order of superposition of the sediments in the Loch Awe Syncline corresponds with the original order of sedimentary superposition. Finally, a recent suggestion of Mr. Hill's is adopted, in which he correlates the extremely low grade of metamorphism of the rocks

of the central part of the Loch Awe Syncline with their high structural position. The hypothesis is that these rocks were not deeply covered during their metamorphism, and accordingly were never raised to any very high temperature.

CORRESPONDENCE.

CRITICAL TEMPERATURES AND CRITICAL CONTROVERSY.

Sir,—Referring to Dr. Johnston-Lavis' letter, I am sorry if I have failed to do him justice. I have a list of eighty of his papers to 1890, none, however, bearing on critical temperatures. If he will send me references to any subsequent ones bearing on the action of superheated water I shall be obliged.

And now I must throw myself on your Editorial leniency and that of your readers.

On the day I received the proofs of the article which appears this month I suffered a serious nervous collapse, and am under strict orders to spare myself in every way, and this just at a moment when the Survey Memoir of Dartmoor makes it incumbent on me to review nearly thirty years of observation of that district; and Mr. Jukes-Browne's papers on "The Making of Torbay" and on "The Torquay Limestones" do the same for about forty years' reflections on the raised beaches and general geology of that district! In addition to this there is a good deal that wants saying about Kent's Cavern.

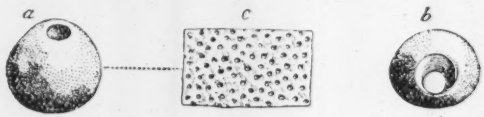
I am very sorry to have broached subjects in your columns which I cannot for the moment now defend, in critical controversy, but I will try to meet any objections, or yield to them, if possible later on. If not in this Magazine, then somewhere else.

A. R. Hunt.

Southwood, Torquay.
March 7, 1913.

PREHISTORIC BEADS.

Sir,—As a supplement to my letter in the Geol. Mag. for March, p. 138, and your reply thereto, pp. 139–43, I send you the following quotation from Sir Charles Lyell's *Antiquity of Man* (4th edition, p. 165). He writes as follows: "In the gravel-pits of St. Acheul, and



a, *b*, *Porosphæra globularis*, Phillips, copied from Lyell's *Antiquity of Man*, 4th ed., p. 165, fig. 22, 1873; *c*, part of same magnified.

in some others near Amiens, small round bodies, having a tubular cavity in the centre, occur. They are well known as fossils of the White Chalk. Dr. Rigollot suggested that they might have been strung

together as beads, and he supposed the hole in the centre to have been artificial. Some of these round bodies are found entire in the chalk and in the gravel, others have a hole passing through them, and sometimes one or two holes penetrating some way in from the surface, and not extending to the other side. Others, like *b* in Figure, have a large cavity, which has a very artificial aspect. It is impossible to decide whether they have or have not served as personal ornaments, recommended by their globular form, lightness, and by being less destructible than ordinary chalk. Granting that there were natural cavities in the axis of some of them, it does not follow that these may not have been taken advantage of for stringing them as beads, while others may have been artificially bored through. Dr. Rigollot's argument in favour of them having been used as necklaces or bracelets appears to me a sound one. He says he often found small heaps or groups of them in one place, all perforated, just as if, when swept into the river's bed by a flood, the bond or string which had united them together remained unbroken.[1]"

J. T. Banton.

Kingston Rectory,
Cambridge.

OBITUARY.

RUSSELL FROST GWINNELL,

B.Sc., Assoc. R.C.Sci., F.G.S.

Born April 21, 1880. Died March 15, 1913.

We deeply regret to record the death of Mr. R. F. Gwinnell, at the early age of 33 years. He had been for some years Demonstrator in Geology under Professor W. W. Watts, F.R.S., in the Imperial College of Science and Technology, South Kensington, and also an Examiner in Geology to the Board of Education. Mr. R. F. Gwinnell was a bachelor living at home with his parents, his father, Mr. Wintour F. Gwinnell, B.Sc., F.G.S., 34 Barrowgate Road, Chiswick, W., being a well-known University 'coach' and an accomplished science teacher of long standing.

MALCOLM POIGNAND.

Born 1850. Died March 2, 1913.

We regret to record the death on March 2, in his 63rd year, of Dr. Malcolm Poignand, of the Beeches, Walsham-le-Willows, Suffolk. He was a member of the Geologists' Association, and took an active interest in geology, having collected many fossils from the Jurassic strata of Dorset and other formations, some of his specimens being referred to in the Proceedings of the Association (vol. ix, p. 204). He received his medical education at St. Bartholomew's Hospital, and subsequently at Aberdeen University, where he took the degree of M.D. in 1878.

"[1] Rigollot, Mémoire sur des Instruments en Silex, etc., p. 16. Amiens, 1854."